CATALOGUE OF SUCCESSFUL HAZARDOUS WASTE REDUCTION/RECYCLING PROJECTS

Energy Pathways Inc. and
Pollution Probe Foundation

Prepared for

Industrial Programs Branch
Conservation & Protection
Environment Canada

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PREFACE

Hazardous wastes can be loosely defined as wastes which, due to their nature and quantity, are potentially harmful to human health and/or the environment and require special disposal techniques to eliminate or reduce the hazard. In 1983, it was estimated that more than 2.75 million tonnes of industrial hazardous wastes were generated in Canada. These included primarily heavy metal solutions and residuals, sludges and inorganic residuals, solvents and organic solutions, contaminated oils and greases, and organic and oily residues.

This publication looks at the twelve industrial sectors responsible for the production of these hazardous wastes. The primary metals, chemicals and allied products, petroleum and coal products and fabricated metals sectors together account for about three-quarters of hazardous waste production, but all the industries profiled in this catalogue are faced with significant hazardous waste management challenges.

There are a number of approaches that can be taken to deal with hazardous wastes. These include: use of nonwaste or zero-discharge technologies (waste abatement); reduction of the volume of waste generated and separation of wastes to enable them to be reused (waste reduction); direct use of a waste stream by the generating plant or by another industry (waste reuse or recycling); treatment to render the wastes inert; and, finally, disposal of nonhazardous or treated wastes.

From an environmental point of view, waste abatement is the ideal approach. However, this may involve considerable capital investment, which may not be justified or possible in many cases. This approach is most easily applied when a new plant is being built and technologies can be selected to minimize the quantity and degree of hazard of the waste.

Most industries, however, do not have the option of building new plants, and must deal with existing facilities and processes. For these industries, reduction, recycling and reuse may be the least expensive means of dealing with hazardous wastes. Frequently, simple housekeeping practices can minimize waste generation and cross-contamination of waste streams.

Implementation of waste reduction, recycling and reuse techniques could substantially reduce the volume of industrial hazardous wastes requiring treatment and disposal. In many cases, waste reduction and recycling can result in significant financial savings. However, many plants continue to pay for treatment and disposal of wastes that need not have been produced in the first place.

Why is this so? A major reason appears to be that many companies are not aware of recycling and reduction opportunities available to them, and lack the manpower and resources to track down technologies and suppliers. Some industries (e.g., metals finishing, pulp and paper, etc.) have had to take action because of regulatory pressure, but even so, many individual plants continue to pay unnecessary surcharges and risk punitive legal action because of their poor waste management practices.

This catalogue was prepared by Energy Pathways Inc. with the assistance of the Pollution Probe Foundation. It highlights examples of successful hazardous waste reduction and recycling projects undertaken by individual companies in a variety of industries. It is based on a review by Pollution Probe of the trade and environmental literature from the past ten years, with an emphasis on recent publications. The intention of the catalogue is to provide companies with useful information on practical, cost-effective reduction and recycling techniques being used by their counterparts in Canada, the United States and abroad.

The cases featured in this catalogue were drawn from a wide range of sources and represent the best of hundreds of examples from the literature that were considered. In evaluating the "success" and usefulness of cases profiled in the literature, the authors considered such things as:

availability of technical information; whether the technology was proven or at a pilot or research stage; payback period/cost-effectiveness of the approach; and the date and country of implementation.

The highest priority was given to proven, readily available techniques with a fast payback and applicability to important waste streams in a given sector. Wherever possible, preference was given to recent, Canadian examples.

In many sectors there were very few examples with enough economic information to allow payback to be judged. In cases where the available information was limited but the approach appears interesting and applicable, we have presented brief "other examples" in addition to the case studies. Where there were virtually no case-specific examples, short or long, we looked at promising or pilot-scale techniques.

The research process revealed that there are few well-documented Canadian examples of successful hazardous waste reduction/recycling projects in the literature. Many trade associations contacted knew little about waste activities in their sectors. In other cases, associations could provide leads on companies active in waste management, but there was nothing in the literature about these companies. Individual companies contacted for information frequently proved reluctant to talk about what they were doing.

It was beyond the scope of this publication to generate original cases, and the majority have been drawn directly from the literature. In sectors with few good recent examples, the authors fell back on examples that are several years old because they represent the best publicly available information.

The paucity of recent published information on Canadian success stories reflects the general reluctance of industry to talk about waste management at all. This attitude contrasts with that of companies such as 3M in the United States, who have gone to great lengths to publicize what their many plants are doing to improve their waste management. There is clearly a need for Canadian industry associations to be more active in disseminating nonproprietary information on hazardous waste reduction and recycling to their memberships.

The cases in this publication are organized according to industrial sector, using the Standard Industrial Classifications of Statistics Canada. As many of the approaches described are applicable in more than one sector, indexes that cross-reference the approaches by waste type and by process are also provided.

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	Oils	12.1	94
	Rinsewater	12.4	97
	Sizing (textiles)	11.1	90
Waste treatment (miscellaneous)	Acids	6.2	57
	Alkalis	6.2	57
	Liquid organic wastes	9.7	80
	Metals	6.2	57
	Paints	6.2	57

1.0 CHEMICALS AND ALLIED PRODUCTS

The chemicals and allied products industries include manufacturers of a wide range of products, including: inorganic or organic industrial chemicals, agricultural chemicals (e.g., fertilizers and pesticides), plastics and synthetic resins, pharmaceutical products, paints and varnishes, soaps and cleaning compounds and a variety of specialty chemical products.

This sector is one of the major producers of hazardous wastes, including: halogenated and nonhalogenated solvents, waste oils, acid and alkaline solutions, heavy metal sludges, inorganic solvents, chlorinated hydrocarbons, phenols, liquid resins, acids, bacteria and biological waste, animal and blood waste, infectious wastes, paint sludges and solids, still bottoms, pesticide wastes, petroleum oil and waste ink.

This industry includes many large companies with their own research facilities. This, combined with the fact that the industry has been under heavy regulatory pressure, has resulted in the development of a number of innovative approaches to reduction and recycling of hazardous wastes.

CASE STUDIES

1.1 ALLIED CHEMICAL (Metropolis, Illinois)

Recovery of Toxic Fluoride Waste Generates A Valuable Raw Material

Background

Allied's plant in Metropolis, Illinois manufactures uranium hexafluoride and sulphur hexafluoride and generates a number of waste streams containing soluble fluoride ions. These are treated with lime to precipitate calcium fluoride and then stored in large surface impoundments to allow the insoluble calcium fluoride and small quantities of other calcium compounds to settle out as a sludge.

Both the sludge and the supernatant are considered hazardous wastes because of their high pH. Because there was no more land available for the construction of new impoundments, Allied needed another way to handle these wastes.

Solution

The sludge is now processed through a wastewaster treatment plant where it is mixed with a waste stream containing dilute hydrofluoric acid. The acid neutralizes the sludge, converting any remaining lime into calcium fluoride.

Allied uses the precipitated calcium fluoride, which closely resembles fluorspar (the naturally occurring form of calcium fluoride), as a raw material in the manufacture of anhydrous hydrofluoric acid at another facility. The clean wastewater which remains is discharged.

Benefits

• The initial investment in 1982 for process modifications was $4.3 million. More than 8000 tons/year of calcium fluoride waste have been recovered and recycled. With net annual cost savings of $1 million, payback was calculated at 4.5 years.

• The technique eliminates contamination of surface water and groundwater from the calcium fluoride waste and the lime.

For More Information...

Contact: Edward Shields
Allied Chemical
Metropolis, Illinois, U.S.A.
(201) 455-5630

Reference: 7

1.2 ASHLAND CHEMICALS (Mississauga, Ontario)

Waste Management System Virtually Eliminates Resin Wastes

Background

Ashland's Mississauga plant manufactures resins for the paint, foundry and fibreglass-reinforced plastic industries. For years, resin wastes from in-process handling, quality control samples, filters, etc. were accumulated and stored, mixed together, in containers at the back of the company property. Every six months or so, these wastes were hauled away to an approved disposal site, at substantial cost.

Solution

The key to Ashland's improvements was putting a motivated individual in charge of waste management in 1979. One of his first actions was to introduce a waste collection system to prevent reusable resins from being wasted.

The system was simple: a clean container, lid and identification tag were supplied at the site where the waste was being generated. Staff were trained to store wastes in the containers provided and fill out the identification tags. The system was pilot-tested in the quality control area and proved so successful that it was extended to the manufacturing operation. A storage area was established, rework tags were processed by the supervisors, and empty rework pails with the identification tag were returned to the waste management department for processing.

In 1984, a simple return system was put in place at the blending tanks to pump excess sampling material back into the tanks. The system consisted of a funnel and valve placed directly below the tank sampler and connected to the inlet side of the pump used for that system. The system was extended to the quality control sampling tanks in 1985. In 1986, a collection system (cans, lids, ID tags) for lab sample wastes was instituted.

Benefits

- Wastes have been dramatically reduced. For example, 31,000 lb of resin wastes requiring disposal were generated from the manufacturing area in 1980. By 1983, this was down to 7,000 lb, all of which was reworked, rather than disposed of.

- The costs of the funnel, valve and labour for the repumping system paid back in one week in most cases.

- Ashland's president estimates that the overall waste management system implemented saved the company upwards of $600,000 in reduced treatment costs and improved plant efficiency in 1985.

For More Information...

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Claude Bourdon
Production Supervisor
Ashland Chemicals
2620 Royal Windsor Drive
Mississauga, Ont. L5J 4E7
(416) 823-1800

References: 5,9

1.3 BORDEN CHEMICAL COMPANY (Fremont, California)

Recovery of Phenolic Resin Wastes and Reuse of Rinsewater

Background

Borden manufactures urea-formaldehyde and phenol-formaldehyde resins at its plant in Fremont, California. Before they are shipped, the organic phenolic resins are filtered to remove large particles. The filters were being emptied into the wastewater stream. Besides wasting raw material, this was the most significant source of contamination in the wastewater.

The plant uses batch processing methods, and reactor vessels must be cleaned out between batches. This generates a large quantity of wastewater containing phenolic resins which had to be processed through the wastewater treatment system.

Borden was using an on-site evaporation pond to remove phenols and other contaminants as a sludge which could be transported to a commercial hazardous waste disposal facility. But there were problems with the pond: it was reaching capacity, and enlarging it would have been prohibitively expensive. As well, continuing to use the pond would require Borden to be classified as a hazardous waste disposal facility, which would involve a number of problems, not the least of which was cost. Finally, there was always the risk that a leak from the pond could contaminate the groundwater and prove costly to remedy.

Solution

In 1982, a large recovery tank was connected to the phenolic resin filter canister. The following year, an improved version was installed in the filter system for the urea resin manufacturing process. Now, when the filters are cleaned, the resin waste is forced under pressure into the recovery tanks and recycled as raw material. The company reports that virtually all waste materials from the filtering process are removed.

The reactor vessel cleaning process was also modified to use a two-rinse technique. The reactor is first rinsed with a small volume of water which picks up most of the phenolic resins. This rinsewater is stored for reuse as a raw material. A second, full-volume rinse completes the cleaning process, and since the phenol content is greatly reduced, the water can be discharged safely into the wastewater stream.

Benefits

- The quantity of organic wastes reaching the wastewater stream from the resin manufacturing process has been reduced by 93%. This has eliminated the need for an on-site evaporation pond. The only additional equipment required was the recovery tank.

- Prior to 1981, resin sludge totalled 350 cu. yd per year. Based on 1985 costs of $150/cu. yd for off-site disposal, annual savings in disposal costs amount to $48,750.

For More Information...

Contact:
Borden Chemical Company
41100 Boyce Road
Fremont, California 94538
U.S.A.
(415) 657-4500

References: 8, 12

1.4 CIBA-GEIGY CORPORATION (Toms River, N.J.)

Process Changes Reduce Heavy Metal and Acid Wastes

Background

CIBA-GEIGY's Toms River plant manufactures a wide variety of dyes and epoxy resins. Wastes generated included airborne, water-borne and solid mercuric wastes, process water containing large amounts of unreacted chromium (35% of the plant's total chromium use), excess unreacted sulphuric acid which was discharged into the wastewater, and 7.3 million lb/year of solid waste sludge containing hazardous chemicals, generated from the operation of an on-site sewage treatment plant. Some 50% of zinc used in dye manufacturing was ending up in the wastewater and solid waste sludges.

The plant's wastes were the subject of considerable public controversy in the area -- in 1984 it was targetted by Greenpeace actions that received widespread media coverage. Regulatory pressure was also steadily increasing; for example, the New Jersey Department of Environmental Protection levied the largest fine ever imposed in the state against the plant ($1.45 million).

Solution

CIBA-GEIGY changed its process for manufacturing aminoanthraquinone to eliminate the need for a mercury catalyst. The company's corporate research group in Switzerland developed a novel chemical pathway that circumvented the sulphonation step in aminoanthraquinone manufacture. Mercury use has been eliminated.

The same research group developed a new solvent-based dye manufacturing process that uses chromium far more efficiently than the old water-based process. The new process, in operation at the Toms River plant, has reduced chromium losses by more than 25%.

The manufacture of dyes containing zinc was discontinued because the volume of dyes produced with this chemical and the overall profit to the plant were too small to justify either the additional cost of waste reduction research or the continued disposal of contaminated wastes.

Through laboratory and plant-scale experimentation, the Toms River plant identified the minimum amount of acid needed to ensure complete sulphonation for each of its dye manufacturing processes, and no longer relies on the old approach of using excess acid.

The plant also reduced the volume of wastewater treatment sludge by using a higher-quality lime that neutralizes more acid per pound. Caustic wastewaters from other industrial plants are accepted if they can be used to neutralize CIBA-GEIGY's own acidic wastewater.

Benefits

- Chromium wastes have been cut by 25%. Although the cost of the solvent-based process is greater, CIBA-GEIGY views the cost as worthwhile when the reduction in long-term liability associated with chromium wastes is considered.

- Mercury and zinc wastes have been eliminated.

- Reduced disposal costs for treatment sludge outweigh the higher costs of high-quality lime.

For More Information:

Contact: CIBA-GEIGY Corporation
Toms River Plant
Route 37 West, P.O. Box 71
Toms River, N.J. 08753
U.S.A.
(201) 349-5200

Reference: 13

1.5 EXXON CHEMICAL AMERICAS (Linden, N.J.)

Floating Tank Roofs Reduce Losses of Volatile Organic Chemicals, Stewardship Program Reduces Organic Wastes

Background

This plant, adjacent to an Exxon refinery, manufactures oil and fuel additives, synthetic lubricants, solvents and specialty chemicals. More than 200 storage tanks at the site were losing large quantities of ketones, acetone, and phenols to the environment. As well, fluctuations in the quantity and quality of the plant's wastewater discharges were interfering with the operation of its on-site treatment plant.

Solution

Exxon installed floating roofs on the 16 tanks storing the most volatile chemicals used at the plant. A floating roof rests on the surface of the liquid being stored in the tank. It rises and falls as the level of the liquid changes, thus minimizing the formation of chemical vapours that are subsequently vented from the tank and lost to the environment.

Exxon also replaced seven standard tank vents with conservation vents that release vapours less freely and less continuously. The vents reduce emissions by between 30% and 75%.

A two-part Stewardship Program was implemented to monitor and control organic chemicals in the wastewater stream. Wastewater sampling stations monitor concentrations and plant operators are quickly made aware of unusual changes so they can trace them back to their source and remedy them. Also, using the monitoring data, each process is charged a portion of the wastewater treatment costs based on its contribution to the load, and waste reduction goals are set for each process.

Benefits

• The floating roofs have reduced emission losses by 90%, saving more than 5 million pounds of chemicals in the first decade of operation. Material savings in 1983 from the floating roofs and special valves were more than $200,000.

• The capital costs of individual roofs ranged from $5,200 to $13,000, and in many cases were repaid in less than a year.

• The Stewardship Program has reduced the level of organic wastes entering the plant's wastewater by 75%.

For More Information...

Contact: Exxon Chemical Americas
Bayway Chemical Plant
P.O. Box 23
Linden, N.J. 07036
U.S.A.
(201) 474-0100

References: 6,14

1.6 3M (Cordova, Illinois)

Ultrasonic Tank Cleaning Means Big Savings

Background

The 3M plant in Cordova manufactures a variety of adhesives, resins and polymers on a batch basis in 4,000-8,000 gallon reactors. Reactor cleaning, which consisted of filling a reactor with caustic or solvent and boiling the solution for one or two days, was costly in terms of time, materials and money.

Solution

Now, a Chemdet Sonic Cleaning system is used to clean the reactors. Cleaning chemicals are pumped under pressure through a twin-nozzled rotating spray head. The process sets up sound waves that break down the chemical solution and enhance its penetrating and dissolving properties.

The closed system clean-up has two phases. In the first, 5 gallons of stripper chemicals are applied at 30-40 lb pressure to break down the waste. Then, up to 300 gallons of caustic or 100 gallons of solvent are sprayed at 600 lb pressure to complete the dissolution and flush the vessel clean.

Benefits

- The cost of the Chemdet system and plant modifications was $36,000. First-year savings in labour, materials and machine costs totalled $575,000.
- 1,000 tons/yr of water pollutants were eliminated. Energy and disposal costs were reduced.

For More Information...

Contacts:

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3M Manufacturing
Cordova, Illinois
U.S.A.

Environmental Engineering and
Pollution Contol Dept./3M
P.O. Box 33331, Box 21-2W
Saint Paul, MN 55133
U.S.A.
(612) 778-4791

Reference: 4

1.7 3M CHEMOLITE CENTER (Cottage Grove, Minnesota)

Recovered Ammonia Sold as Valuable Fertilizer

Background

3M's Chemolite Center plant makes magnetic oxides for recording products. Ammonium sulphate, a by-product of the process, was being discharged to the wastewater treatment facility that serves the entire Chemolite complex. However, mixing with gallons of other wastewater diluted the ammonium sulphate so much that there was no practical way to remove or recover it. It passed through the system and into the nearby river virtually untreated.

State regulations required a reduction in the ammonia in the Chemolite effluent. 3M decided to recover it before it got into the wastestream.

Solution

A vapour compression evaporation system was chosen because it could produce marketable, commercial-quality fertilizer from the recovered ammonia. The waste stream is sprayed on steam-carrying tubes, gradually stripping the ammonia until a 40% solution is achieved. This solution is pumped to holding ponds and sold as fertilizer by the truck tank lot.

Benefits

- The need for pollution control equipment was eliminated, saving $1 million.

- The cost of the vapour compression evaporator was $1.5 million. Fertilizer sales produced annual revenues of $150,000.

For More Information...

Contacts:

Carmal Bongiovanni
Manufacturing
Chemolite
Cottage Grove, MN

Environmental Engineering and
Pollution Control Dept./3M
P.O. Box 33331, Bldg. 21-2W
Saint Paul, MN 55133
U.S.A.
(612) 778-4791

Reference: 3

1.8 USS CHEMICALS (Ironton, Ohio)

Recovery and Reuse of Cumene Means Big Savings

Background

USS Chemicals' Haverhill plant, which manufactures phenol and secondary products, acetone, bisphenol A and aniline, is the largest phenol-producing plant in the United States. The Phenol I unit (in operation since 1969) produces industrial-grade phenol, while the Phenol II unit (in operation since 1979) produces a higher grade.

The company wanted to expand operations but still comply with air emissions regulations. This, combined with rising cost of cumene, prompted them to look for ways of reducing emissions of organic vapours from the cumene oxidation process (an intermediate stage in the manufacture of phenol).

Solution

A resin adsorption system that soaks up cumene vapours for subsequent reuse was installed along with the Phenol II unit in 1979, to service both units. The system uses a new type of resin that can effectively and economically adsorb cumene vapours.

At the suggestion of a plant operator, a surplus condenser was installed in the Phenol I process area in 1983. It recovers uncontrolled vapours that had been escaping from a pressure control vent. (The employee's idea originated through a corporate suggestions program for non-management employees that rewards successful suggestors with a percentage of the savings realized from implementation of their ideas.)

Benefits

- Cumene emissions from Phenol I were reduced from 900,000 lb/year to 185,000 lb/yr; the estimated annual saving was around $175,000.

- The condenser, which cost $5,000, saves $100,000 worth of cumene every year.

For More Information...

Contact:

USS Chemicals
Haverhill Plant
P.O. Box 127
Ironton, Ohio 45638
U.S.A.
(614) 532-3420

Reference: 15

OTHER EXAMPLES

1.9 DOW CHEMICAL CANADA INC. (Sarnia, Ontario)

Over the years, Dow Chemical has developed several waste reduction technologies. These include:

High-Temperature Incineration

The manufacure of chlorinated compounds such as carbon tetrachloride, perchlorethlylene and vinyl chloride produces a variety of highly chlorinated by-products, ranging from liquids to highly viscous tars. If these are incinerated, highly corrosive chlorine and hydrogen chloride are produced. In Dow's process, a source of hydrogen is injected into the feed as well as air. This converts almost all the chlorine to hydrochloric acid which is used elsewhere in the Sarnia plant. The small amount of chlorine which remains is removed in a scrubber containing caustic soda.

Recycle of Brine

Dow produces propylene oxide by the chlorohydrin process, in which propylene chlorohydrin is converted to propylene oxide by reaction with caustic soda contained in a stream that is nearly saturated with salt. The main by-product of the chlorination process is also salt. Even after treatment to remove organics, the clean brine poses a problem, as it increases the salinity of the river into which it is discharged.

Despite the fact that brine recycling is difficult because of the presence of sodium sulphate and dead bacteria from the biological treatment process, Dow's Sarnia Divison has successfully found economical ways to overcome both problems. Brine is recycled as feed for the chlor-alkali process used to produce chlorine and caustic soda.

Contact: Dr. Harold Quinn
Director, Environmental Science
Dow Chemical Canada Inc.
P.O. Box 1012, Modeland Road
Sarnia, Ontario
N7T 7K7

Reference: 11

1.10 PPG INDUSTRIES (Cleveland, Ohio)

PPG needed to control emissions of volatile organic compounds (VOC) in order to comply with environmental regulations. As well, being located in a semi-residential area, they needed to control emissions of odours to avoid complaints from neighbours.

The solution they chose was a Re-Therm regenerative thermal incinerator, supplied by REECO (Regenerative Environmental Equipment Co.). The unit, which incinerates solvent-laden gases, has the capability of eliminating 80% of the plant's emissions, including those of a planned expansion. The unit is self-sustaining -- heat from incineration is stored in a stoneware bed and used to preheat incoming gases to close to incineration temperature. Supplementary fuel is needed only for the burner pilot.

Contact: PPG Industries, Cleveland, Ohio

Reference: 10

1.11 3M INDUSTRIAL TAPE PLANT (Knoxville, Iowa)

Direct recovery of airborne solvent wastes was not economically practical for 3M's industrial tape plant, so the company modified two existing boilers to burn the solvent-laden exhaust from a process oven. Solvent-laden air that formerly went up the stack is now ducted to the converted boilers, where it substitutes for combustion air.

Under normal plant operating conditions, more than 20% of the process and other steam used in the plant is generated by burning solvent vapours. The boiler incineration facilities cost $270,000 including installation, and saved $155,000 in the first year in avoided natural gas and fuel oil costs.

The successful Knoxville operation prompted a similar installation at a plant in St. Paul, MN, where three boilers are fed from three process ovens, resulting in significant savings.

Contact:	William Boyd or William Garr Manufacturing, 3M Knoxville, IA	3M Environmental Engineering and Pollution Control Dept. P.O. Box 33331, Bldg. 21-2W Saint Paul, MN 55133 (612) 778-4791

Reference: 1

1.12 3M RIKER LABORATORIES (Northridge, California)

This plant was coating pharmaceutical tablets with solvents, but solvent emissions had the potential to exceed air pollution limits under a forthcoming state regulation. To reduce emissions, 3M developed a water-based coating to replace the solvent coating, and installed different spraying equipment in the coating machine.

The pumping mechanism and control systems were also modified. The spray system was changed from an oxygen-free to an oxygen-utilizing system in order to ensure quick and precise application of coating. Since water does not evaporate as quickly as organic solvents, the heating capacity of the process was also increased to ensure that the tablets wouldn't become soggy.

These equipment changes cost some $60,000, but eliminated the need to buy $180,000 worth of pollution control equipment. Eliminating the need for solvents saved $15,000 annually and prevented 24 tons of air pollution. In addition, less cleanup time is required with the new system, and worker comfort has been improved by the elimination of solvent fumes.

Contact:	Byron Seelig 3M Laboratory St. Paul, MN	3M Environmental Engineering and Pollution Control Department P.O. Box 33331, Bldg. 21-2W Saint Paul, MN 55133 (612) 778-4791

Reference: 2

2.0 ELECTRIC AND ELECTRONIC MACHINERY

This industrial sector includes manufacturers of electric appliances, lighting, telecommunications equipment, transformers and switchgears, wiring and batteries. Wastes include halogenated and nonhalogenated solvents, heavy metal solutions, acid and alkaline solutions, waste oils, cyanide solutions, phenolic solutions, metal finishing sludges, organic solids and toxic metal sludges.

The literature contains a number of good examples of waste reduction and recycling in this sector, both in the production of electronic machinery and in the recycling of machinery itself. Industry associations are aware of waste reduction activities within the industry, and there are good examples in the recent literature, including the ones profiled in the following pages.

CASE STUDIES

2.1 AEROVOX CANADA LIMITED (Amherst, N.S.)

Distillation and Recycling of Trichloroethylene Wastes

Background

Aerovox manufactures oil-filled capacitors. The company uses trichloroethylene (TCE) as a solvent to degrease the capacitors and ends up with a waste that is about 30% TCE and 70% dioctyl phthalate (DOP).

Aerovox wanted to find the most cost-effective and practical way to dispose of this waste, and hired a project worker through an ON-SITE pilot project supported by Environment Canada and Employment and Immigration Canada. This project worker studied various means of separating out the solvent and recommended a wiped film still from Pope Scientific.

Solution

The wiped film still was installed in late 1986. It uses a two-stage vacuum distillation process to separate out the TCE from the DOP. The unit uses teflon brushes to "wipe" the solvent mixture onto the interiors of high-temperature glass tubes that are heated and subjected to a vacuum to vaporize the TCE. The TCE vapours are then passed over cooler coils to cause them to condense out.

Benefits

- The unit separates out more than 99.5% of the trichloroethylene, which is sufficiently pure to be used again. The DOP can be combined with No. 2 fuel oil and burned as a supplementary fuel.

- The unit cost approximately $100,000. Payback is estimated at about one year.

- The unit can be applied to a wide variety of solvents in different industries. It requires only a few hours a day of labour for operation and supervision.

For More Information...

Contact:

Mr. Kirit Patel
Chief Engineer, Pope Scientific Inc.
N 90 W 14337 Commercial Drive
Menomonee Falls, Wisconsin
U.S.A.
(414) 251-9300

Mr. Ben Griffin
General Manager
Aerovox Canada Limited
P.O. Box 250
Amherst, N.S.
(902) 667-3886

Reference: 21

2.2 C3 INTERNATIONAL (Bloomington, Minnesota)

Reclaiming Rinsewaters from Semiconductor Manufacture

Background

This company manufactures semiconductor devices used in the computer industry. The production process involves electroplating several coatings onto a special ceramic substrate. The plating metals used are permalloy (nickel-iron), nickel, copper and gold.

After each plating bath the devices are rinsed in ultrapure water. Copper and nickel, which occur in the effluent from three of the baths, are heavy metals which are classified as hazardous wastes, and are therefore subject to local discharge limits (2.07 mg/L for copper and 2.38 mg/L for nickel). The costs incurred in discharging these wastes were rising, and quality consistency was becoming an increasing problem.

Solution

A complete reclamation and waste treatment system was designed and installed.

Rinsewater Reclamation System

Contaminated rinsewaters are pumped through a series of purifying processes and then into a recirculating loop. An activated carbon filter is followed by a reverse osmosis unit to remove organic contaminants, which are accumulated in storage tanks and then directed to the waste treatment system.

Ninety per cent of the stream is recovered as purified water, purified further by filtering and deionizing and then directed to the polishing system, which renders it suitable for reuse as ultrapure rinsewater. The remainder is recirculated to the storage tank and the deionizers are regenerated.

Make-up Water System

This subsystem purifies city water by a combination of filtration and reverse osmosis to provide make-up water to replace water lost to the waste treatment system. It also serves as an emergency source if the rinsewater reclamation system has to be shut down.

Polishing System

The purified water from the rinsewater reclamation system and the make-up water system are blended and sent to be polished by a combination of exchange deionizers and filters. The water is then put in a storage tank, where it is continuously purified by recirculation through ionizers, filters and an ultraviolet irradiation unit to minimize bacterial growth.

Waste Treatment System

The dumps from the plating bath, regenerant waste from the deionizers in the rinsewater reclamation system and the polishing system, and the concentrate streams from the reverse osmosis and ultrafiltration units in the rinsewater reclamation system are all collected in a storage tank. Sodium hydroxide and calcium chloride are added to precipitate a heavy metal hydroxide sludge. After dewatering, the sludge is hauled to a waste disposal site and the effluent, which now meets local discharge limits, is sent to the sewer.

While reverse osmosis, ultrafiltration, automatic deionization and activated carbon filtration have all been extensively used to produce ultrapure water for the electronics manufacturing industry, reclaiming the rinsewater represents a new approach. The total operating cost for all four subsystems is reported to be $251.31 per day.

Benefits

- Reducing the discharge of heavy metal contaminants has allowed the company to meet local discharge limits and avoid the costs involved in purifying large quantities of water.

For More Information...

Contact: C3 International
3423 N.E. Maplewood Drve
Minneapolis, M 55418
U.S.A.

Reference: 20

2.3 DATA GENERAL CORPORATION (Clayton, North Carolina)

Avoiding Landfill By Marketing Hazardous Wastes

Background

Data General manufactures printed circuit boards for computers, generating several hazardous waste streams with a high concentration of heavy metals. These include waste from etchant and plating baths, the residue from solvent cleaner reclamation, and process water contaminated with copper, nickel and lead.

Solution

In 1981 the company instituted a comprehensive policy of dealing with its wastes to minimize the quantity of waste to be landfilled. Their approach is to market spent chemicals and wastes rather than trying to minimize the amounts produced. This allows the company to avoid making process changes. Modifications have included:

1. Recovery of waste where this can be done cost-effectively. Markets were found for several untreated waste streams: spent cupric chloride and ammonia etchants, some of the spent plating baths, copper sulphate crystals produced by regenerating the sulphuric peroxide bath, and the residue from the solvent recovery process.

2. Treatment of waste streams to convert them to a marketable form. A spent copper bath is treated to produce a sludge containing 90% metallic copper, and process water is purified by cross-flow filtration and the wastes converted to a heavy-metal hydroxide sludge from which copper can be recovered and sold. The treated water is then used for irrigating forest land owned by the company. Surface and groundwater are monitored at the site to ensure that the amount of copper applied does not exceed regulated limits. Any remaining waste streams, including those containing strong chelating agents, are batch-treated with sodium sulphide to produce a sludge which is dewatered, yielding considerable savings in disposal costs.

3. Incineration of some lead-containing wastes.

The modifications took three years to implement. Remaining wastes are disposed of in a conventional landfill.

Benefits

- Wastes have been reduced by 400 tons per year, reducing the risk of soil and groundwater pollution by heavy metals. Reclamation of wastes conserves raw materials and further reduces costs.

- The company estimates total process cost savings as a result of all modifications to be more than $100,000 per year, and disposal costs have been reduced by $80,000 per year, in return for a capital investment of less than $50,000 for the sludge recovery program. Payback on the modifications, which took three years to implement, was 1.5 months.

- Equipment downtime has been reduced by 75%.

- No extra personnel are required and no additional maintenance costs are incurred.

For More Information...

Contact:
Stan Taylor
Data General Corporation
Clayton, North Carolina
U.S.A.
(919) 553-5076

Reference: 23

2.4 HAMILTON BEACH DIVISION OF SCOVILL, INC.
(Clinton, North Carolina)

Three Steps to Reduce Solvent Wastes

Background

This company, which manufactures small electric appliances, uses the solvent 1,1,1-trichloroethane to degrease the metal stampings it produces. Waste solvent is collected in 55-gallon drums, and these were accumulating. The company looked for ways to safely dispose of the waste without incurring high landfill costs.

Solution

In order to reduce the risk of pollution from a solvent spill, a building with a central recess in the floor designed to contain spills was constructed for housing the waste drums. This storage building was provided with equipment for use in the event of a spill.

The company contracted with Ashland Chemical Company to collect and recycle the accumulated waste and all future waste generated (an amount anticipated to reach about 38,000 lb/yr). The solvent is distilled and returned to the company for reuse.

Finally, the company has been able to substitute a water-soluble synthetic cleaner manufactured by the Cincinnati Milacron Company in some of the applications for which the organic solvent was used.

Benefits

- The payback period for these modifications, which took three months to implement, was less than six months.

- The special storage building cost $3,000 to construct and $250 to equip, and costs about $100 per year to operate.

- Substitution of recycled solvent, which costs half as much as the virgin product, has produced further savings.

- The water-soluble solvent is a less expensive alternative, and therefore the decrease of 30% in the consumption of organic solvent, besides being a health and safety benefit to the employees and less of an environmental hazard, represents a cost saving to the company.

For More Information...

Contact:
Guy Tilford
Hamilton Beach Division
Scovill, Inc.
Clinton, North Carolina.
(919) 592-0121.

Reference: 21

2.5 3M ELECTRONIC PRODUCTS DIVISION (Columbia, Missouri)

Mechanical Cleaning of Copper Sheeting for Electronic Circuits

Background

This 3M company manufactures electronic circuits by photographic printing onto flexible copper sheeting. Before printing, the copper sheeting must be chemically cleaned with ammonium persulphate, phosphoric acid and sulphuric acid to dissolve any contaminants. Cleaning was previously done by means of a chemical spray, but this led to the production of quantities of hazardous liquid waste, which required costly handling and disposal.

After printing, a developer solvent is sprayed onto the metal, which is then rinsed with water. The solvent-contaminated wastewater was previously discharged into the local sewer.

Solution

First, a specially designed machine was introduced to replace the chemical cleaning spray. Rotating brushes scrub the copper sheeting with pumice, a fine abrasive powder, leaving a nonhazardous sludge which is suitable for disposal in a conventional sanitary landfill site. This equipment is suitable for use in industries which require chemically clean sheet metal.

The second modification involved the installation of a stainless-steel decanter to hold the solvent-contaminated wastewater for a short time, allowing the solvent to settle out. The water is then discharged and the solvent is distilled and recycled to the developing process.

Benefits

- The introduction of the cleaning machine has eliminated 40,000 lb of hazardous liquid waste every year, which represents a considerable cost saving to the company. Total first-year savings in raw materials and disposal and labour costs were $15,000. The cost of the machine was recouped in about three years.

- Plant production is increasing yearly, and therefore cost savings continue to rise and the volume of hazardous waste which is avoided becomes more significant.

- The purchase and installation costs of the decanter system, which totalled $4,000, were more than offset by savings of $20,400 in solvent costs over the first 4 years of use.

For More Information...

Contact:

Mike Koenigsbergen
3M Environmental Engineering
and Pollution Control Dept.
P.O. Box 33331, Bldg 21-2W
Saint Paul, Minnesota 55133
U.S.A.
(612) 778-4523

References: 16, 17, 24

2.6 WINCHESTER ELECTRONICS-USECO (Van Nuys, Californa)

Reclaiming Oils Saves Money

Background

This machine shop, which is a division of Litton Systems, uses thousands of gallons of cutting oil and hydraulic and lubricating oils every year. All pick up contaminants easily, and must frequently be replaced. Waste oils previously had to be stored prior to disposal under contract.

Solution

The company now uses a compact, portable unit, the Phors 180, manufactured by Aquanetics Inc. of Farmingdale, New York. It is designed to reclaim mineral-based and synthetic oils without altering their mechanical or lubricating properties.

Used cutting oil is centrifuged and pumped into a settling tank to separate out gross contaminants and water. It is then transferred to a large processing drum from where it enters the reclaimer. After processing, the oil is piped to a holding tank before being reused. The unit can process up to 180 gal/h. Set-up time is minimal, requiring only electrical and oil hose connections.

Benefits

- Consumption of cutting and hydraulic oils has been reduced by more than 90% and waste disposal is no longer required.

- Winchester has found that the reclaimed oils are purer than newly purchased oils, and that downtime and wear and corrosion of equipment are reduced.

- The payback period was 10 months.

For More Information...

Contact:	Winchester Electronics-Useco Van Nuys, California	Reference: 28

OTHER EXAMPLES

2.7 DIGITAL EQUIPMENT CORPORATION (Tempe, Arizona)

Digital manufactures printed circuit boards using several production processes. In order to conserve resources and reduce the cost of treating the rinsewater, the company installed a centralized process water treatment system designed by Lancy International.

The system uses electrolysis to recover 92 % of the dissolved copper in the dragout rinses, and an atmospheric evaporator to recover and recycle approximately 95% of the chromic acid dragout from the etch line. Digital uses a lime slurry, obtained as a waste product from a local acetylene gas manufacturer, to neutralize the acid wastes.

The recovery system is installed underneath the production floor so that the effluents can reach the treatment tanks by gravity flow and do not require pumping. While no economic details of the system are provided, its benefits include conservation of copper and chromic acid, improved pollution control and a reduction in sludge disposal costs.

Contact: Digital Equipment Corporation
Tempe, Arizona.

Reference: 25

2.8 INTERNATIONAL BUSINESS MACHINES (IBM)

In the manufacture of magnetic discs, several of the processes involved, such as polishing, machining and cleaning, require the use of solvents. These are supplied from remote tank farms and stored in a day tank adjacent to the plant.

Each time the day tank was filled, saturated vapour was released into the atmosphere through a vent. By installing a computerized solvent control system, the company has eliminated the need for a day tank, which saves money and avoids hydrocarbon emissions.

Contact: IBM

Reference: 19

2.9 NORANDA INC. (Noranda, Quebec)

Noranda recycles electronic equipment to recover copper and precious metals. Electronic equipment is melted down along with other material. The product is a copper anode, a block of copper that is 99.4% pure. The remaining 0.6% is precious metals (e.g., gold, platinum, silver) and impurities. Copper anodes are sent to CCR, a Montreal refiner, where they are refined to 99.99% pure copper.

Contact: L. Jacques Moulins
Noranda Inc.
Noranda, Quebec

Reference: 9

2.10 SANYO ELECTRIC COMPANY LTD. (Sumoto City, Hyogo, Japan)

Sanyo Electric Company is spearheading a program in Japan to recycle nickel cadmium (Ni-Cd) batteries. The program includes a promotional campaign to encourage industrial and domestic consumers to return used batteries and efforts to find an efficient way of recovering the metals from them.

As part of this program, a group of recycling companies has been working since 1980 on ways of recovering the metals from Ni-Cd batteries from security equipment, such as emergency lighting and automated alarm systems. Two companies are already in operation and another is expected to start up shortly. The total weight of sealed batteries collected in 1984 was reported to be 294 tonnes, which represents slightly more than 10% of the total weight of sealed Ni-Cd batteries marketed for domestic use in Japan and a large proportion of the security batteries sold.

One of these companies, the Kansai Catalyst Company Ltd., uses the following method to retrieve cadmium from the used batteries (the other companies employ slight variations of the same method). The batteries are put through a peeling machine to separate the cells from the casings. The cells are then fed continuously into a rotary kiln, where cadmium compounds are dehydrated. This produces a gas containing cadmium oxide, which is then cooled to below 100°C, causing the cadmium oxide to sublimate into a powder which can be collected.

The remaining gas is passed through a filter and an electric precipitator to recover more cadmium oxide before being discharged. The cadmium oxide can be converted to cadmium sulphate and other salts which, in turn, can be used as a source of metallic cadmium for use in the manufacture of new batteries. The nonvolatile nickel is discharged from the bottom of the kiln.

The Ni-Cd batteries carry a special symbol to enable users to distinguish them from dry cells. It is hoped that this will assist in the recovery effort. While this program has met with considerable success, a similar program for recycling domestic batteries has not succeeded, mainly because it did not prove to be cost-effective.

Contact:

Yasuo Ohira
Sanyo Electric Co. Ltd.
222-1, Kaminaizen
Sumoto-City
Hyogo, 656, Japan

Reference: 27

2.11 W.C. WOODS COMPANY LTD (Guelph, Ontario)

This company has been successfully using a powder-coating process to paint its freezers for a number of years. A specially formulated fusible paint powder is applied to the appliance in an enclosed spray booth. The appliance is then heat-cured in an oven to fuse the paint to the surface of the appliance. This technique has wide application in the automotive as well as in the appliance-manufacturing industry.

The system has a number of advantages. Since the paint is a solid, it contains no solvents to generate emissions. It is easily recycled, since the waste can be collected more easily than conventional liquid paint waste, thus saving on the cost of raw materials. No paint sludge is produced and no large volumes of wastewater are generated.

Although powder coatings need a curing temperature which is 20°F higher than that required for conventional liquid paint, energy costs for the whole process are still lower, since the hot air from the oven does not contain solvent emissions and can therefore be recycled. Since less material and less labour are also required, the operating costs of this process are lower than those of a conventional paint line.

Contact: W.C. Woods Company Ltd. Reference: 18
Guelph, Ontario.

3.0 FABRICATED METAL PRODUCTS

The fabricated metal products industries include manufacturers of a variety of structural, ornamental and architectural metal products, hardware, wire and coated metal products. Machinery and transportation equipment are excepted.

Hazardous wastes of concern to this sector include: halogenated and non-halogenated solvents, paint sludges, heavy metal sludges, acid and alkaline solutions, cyanides, waste oils, chlorinated solvents, halogenated still bottoms, emulsified oils, polychlorinated organics, explosive wastes and inorganic sludges.

Certain of these wastes are highly toxic, and the electroplating and coatings industries in particular have recently been under heavy regulatory pressure to reduce their hazardous wastes. As a result, there has been considerable activity in this sector, and the literature contains a number of examples of successful reduction and recycling activities. Many of these approaches, such as solvent recovery, have application in other industries, particularly in industries such as machinery and transportation equipment manufacture, where electroplating and coating processes are used.

CASE STUDIES

3.1 ADVANCE PLATING COMPANY (Cleveland, Ohio) RELIABLE PLATING WORKS (Milwaukee, Wisconsin)

Ion-Exchange Chromium Recovery Means Savings

Background

Advance plates chromium onto small die castings and Reliable onto various types of household paper dispensers. In 1980 both companies installed an ion-exchange system, the Innova Chrome Napper™, marketed by McGean Chemical Company of Cleveland, Ohio.

Solution

The unit comprises a number of ion-exchange cells, each consisting of an outer stainless steel mesh cathode lined with a synthetic membrane which encloses a platinum-plated titanium anode. When rinsewater is pumped into the cells, chromium and sulphate ions enter the anode compartment and the clean water returns by gravity flow to the rinse tank. The anode compartment is drained periodically and the contents recycled to the acid plating tank.

Benefits

- Chromium consumption at both plants has been reduced by 80-90%, water consumption has dropped by 99% and energy requirements are lower.
- The units cost $15,000 and paid back in 2 years.
- The plants now meet regulatory limits for chromium discharge and no longer pay sewer discharge fees or sludge treatment and disposal costs.
- The greater purity of the final rinsewater has improved the quality of the product.

For More Information...

Contact:	Advance Plating Company Cleveland, Ohio U.S.A.	Reliable Plating Works Milwaukee, Wisconsin U.S.A.

References: 31, 36, 40

3.2 ARTISTIC PLATING COMPANY (Milwaukee, Wisconsin)

Recovering Gold By Electrodialysis

Background

This job shop specialises in the plating of precious metals, mainly onto plumbing accessories. Build-up of impurities in the gold bath was occurring because of the nature of the raw materials used in the plating system.

Solution

A closed-loop system was installed, incorporating an electrodialysis unit to concentrate and remove the gold from the drag-out tank. Any gold which enters the rinse is recovered by means of an ion-exchange column. Organic contaminants are precipitated by carbon treatment and then filtered out.

Benefits

- The amount of gold collected varies between 7.6 and 9.5 g/L, depending on the amount plated.

- Installation costs (reported in 1982) were $21,050 for a 15-cell-pair unit, and annual operating costs were $3,345. The payback period was 9 months.

For More Information...

Contact: Artistic Plating Company
Milwaukee, Wisconsin.

References: 35, 41

3.3 INDUSTRIAL ELECTRO-PLATING (Don Mills, Ontario)

Recovery of Chromium From Plating Bath

Background

Industrial specializes in chromium-plating parts for wheelchairs and other patient-care devices. The rinsewater previously had to be diluted with water at a rate of 10 gallons per minute in order to reduce the chromium content to 5 ppm to meet local effluent regulations.

Solution

The company installed a system designed and built by Eco-Tec Ltd of Pickering, Ontario to recover the chromic acid from the plating bath. The unit, Model C12-X Chromic Acid Recovery Unit (CRU), operates as a closed-loop system. The rinsewater is filtered to remove solids and then pumped through three reciprocating-flow ion-exchange columns. The first contains a cation-exchange resin which adsorbs cationic contaminants. An anion-exchange resin removes the chromate and polychromate ions, and the water is then reused for rinsing.

The cation resin is regenerated with sulphuric acid and the anion resin with sodium hydroxide, after which the effluent passes through a second cation-exchange bed, where a concentrated chromic acid solution is collected. The company is able to purify sludge during weekends, when the the plating line is not operating.

Benefits

- Chromic acid is recovered and purified at the rate of 2300 kg per year, saving the company at least $11,000 every year in raw material costs. Materials for the recovery system cost $8,055 per year.

- The level of chromium in the plant effluent is reduced to less than 2.0 ppm. This practically eliminates the need for chemical treatment, which saves a further $5,400 per year. The cost of sludge disposal is reduced by $400 each year.

- No extra water is required to dilute the effluent to meet local regulations. This has reduced water consumption by 2.4 million gallons per year, saving a further $6,980.

- The unit is able to maintain a flow rate which ensures thorough rinsing of the plated parts, many of which are tubular in shape, and therefore difficult to rinse.

For More Information...

Contact: Brian Dos Ramos
Industrial Electro-Plating
Don Mills, Ontario

References: 34, 43

3.4 PIONEER METAL FINISHING, INC. (Franklinville, New Jersey)

Closed-Loop, Batch Process Conserves Water and Chemicals

Background

The rinsewaters from this electroplating operation are contaminated with metals and cyanide, which were treated in a single-pass, continuous system. However, problems with monitoring and control habitually caused the concentration of some pollutants in the effluent to exceed regulated limits. This threatened the local marshland ecosystem and the surface and groundwaters in the adjacent area.

Solution

In order to meet more stringent new regulations, a closed-loop, batch process system manufactured by Zerpol was installed. The wastewater is now held in large tanks, allowing more time for chemical reactions to be completed. After the solids are removed, the water can be reused in those parts of the process which do not require distilled water. This modification is reported to be applicable to a wide range of metal-plating operations.

Benefits

This modification, together with a number of housekeeping improvements, have led to significant savings in both costs and materials.

- The cost of the chemicals required for water treatment was reduced by 50-75%.

- The amount of water required was reduced from nearly 12,000 gal/day to 500 gal/day (the amount required to make up evaporation losses), with the result that the water bill has been cut by 90%.

- The amount of sludge produced has been reduced by 50% or 40,000 gal/yr.

- While the cost of facilities and equipment totalled $210,000, savings are $29,400/yr on pollution control and $58,460 on waste disposal.

- Health and safety conditions for plant personnel are reported to be improved.

For More Information...

Contact:
Harry DeSoi
Pioneer Metal Finishing, Inc.
Franklinville, New Jersey
U.S.A.
(609) 694-0400

Reference: 39

3.5 SOMMER METALCRAFT CORPORATION (Crawfordsville, Indiana)

Closed-Loop Evaporator Allows Chrome-Plating Losses to Be Cut

Background

This company custom paints and plates steel wire and tubular products which are used in the manufacture of household products, such as bird cages and oven racks. Between 150 and 200 lb of chromium were previously lost from the plating bath each shift.

Solution

To reduce these losses, and to cut down the cost of treating the waste and disposing of more than 172,000 lb of sludge every month, Sommer installed a closed-loop evaporator, supplied by the Pfaudler Division of Sybron Corporation, to recover chromium from the rinse tanks and return it to the plating bath. This system also enabled 100 gallons of water to be recycled to the fourth and last counterflow rinse tank every hour.

Water is continually drawn from the plating bath to maintain a constant level, and the heat contained in this water can be returned to the evaporator. While some contaminants, such as copper, are removed by ion exchange, there is still a gradual build-up of contaminants in the bath. It is therefore decanted approximately every four years in order to dispose of the accumulated sludge and contaminated fluid.

Benefits

- The amount of chromium used in the plating process was reduced by 180 kg/day, which represents a saving (in 1982 US$) of $100,000 per year in raw material.
- The high costs associated with waste treatment and sludge disposal have been greatly reduced.
- The cost of the evaporator was recovered within the first year.
- The maintenance requirements of this system are reported to be low.

For More Information...

Contact: Sommer Metalcraft Corporation
Crawfordsville
Indiana

References: 30, 32, 37

3.6 SUN POLISHING AND PLATING (Toronto, Ontario)

Electrolytic Recovery of Nickel from a Plating Operation

Background

This company plates nickel onto lighting fixtures. They were concerned about the loss of nickel through dragout in the first standing rinse.

Solution

A Chemelec electrolytic recovery unit was installed in early 1984. The unit was supplied by BEWT Metal Recovery Systems Ltd of Whitby, Ontario.

The electrolytic chamber contains expanded steel mesh electrodes in a bed of inert glass beads. The bed is fluidized as the rinsewaters are pumped through, immersing the electrodes. The scouring action of the beads on the surface of the electrodes ensures that the ion concentration is maintained. The metal forms a deposit on the electrodes.

Water from the first rinse is circulated constantly through the unit in order to maintain the nickel concentration in the inflow to the unit at a minimum of 300 ppm. By means of successive rinses the nickel concentration is reduced to about 3 ppm. The rinsewater can then be discharged, since it meets the regulatory limit of 5 ppm of nickel. The electrodes are periodically removed when the deposits reach sufficient thickness, and the nickel is returned to the plating tanks.

Benefits

- The company estimates that this system allows recovery of about 18 kg of nickel per week, which is the amount of previous dragout losses in the first standing rinse. (The current cost of nickel is about $7 per kg).

- The greatest saving results from the avoidance of waste-treatment costs.

- The payback period is projected to be about 5 years.

- The unit is easy to operate and requires less than 1/2 hour each day to maintain. It is also capable of recovering silver, gold, cadmium and copper.

For More Information....

Contact: Mark Horvatin
Sun Polishing and Plating Ltd.
Toronto, Ontario

References: 29, 38

OTHER EXAMPLES

3.7 ALLIED FINISHING (Grand Rapids, Michigan)

This company chromium-plates zinc die castings and sheet metal stampings for a number of industries, including the automotive industry. When an evaporation system was installed to concentrate chromium in the effluent, the quantity of chromium salts required in the plating process dropped by approximately 84%, promising a payback within 2 to 2.5 years. An additional benefit was a decrease of 15-20% in the volume of sludge produced, resulting in considerable savings in waste disposal costs.

Contact: Allied Finishing
Grand Rapids, Michigan
U.S.A.

References: 33, 37

3.8 NORANDA INC. (Noranda, Quebec)

Many electroplaters send metal sludges that are precipitated from plating baths to waste treatment companies for disposal. Noranda will recycle copper sludges.

First, the sludge is tested to make sure it contains no PCBs, other carcinogens, beryllium, etc. (Noranda refuses to accept sludge that it cannot recycle safely.) Enough dry, unrefined copper-containing material is then added to the sludge to form a mixture containing no more than 10-12% water. This mixture is fed into a continuous smelting reactor, the copper contained in the sludge is recovered and the gangue materials are fixed in a glassy slag.

Contact: L. Jacques Moulins
Noranda Inc.
Noranda, Quebec

Reference: 42

4.0 LEATHER AND LEATHER PRODUCTS

There appears to be little hazardous waste management activity in the leather and leather products industry in Canada. It seems that economic difficulties and pressure from foreign competition have been undermining the industry to the point where waste management is seen as a low priority.

However, the hazardous wastes from the tanning industry are not something that can be easily ignored. Tanning sludges, fats, greases, halogenated and nonhalogenated solvents as well as sludges from wastewater treatment are all hazardous wastes generated by this industry.

Much of this waste is unnecessary, and could be avoided through economically attractive reuse and recycle technologies. Chromium recycling, salt recovery and collection of protein and sulphides are all viable source reduction options. However, there seem to be virtually no examples in the literature of waste reduction in Canadian companies in this sector.

A number of innovative techniques and technologies which have been developed in Europe are profiled in this chapter. Many of these involve expensive changes, but the European leather industry has been willing to make the necessary investment to reduce hazardous wastes and maintain the health of the industry in the light of strict environmental regulations.

CASE STUDIES

4.1 BLUE SIDE COMPANY (St. Joseph, Missouri)

Recycling Sulphides Using the Darmstadter Process

Background

The unhairing bath which is used to remove hair and other unwanted proteins from hides prior to tanning contains a solution of lime and sodium sulphide. In order to recover the sulphide for reuse in the unhairing tank, this American tanning company has adopted the Darmstadter process, developed in West Germany.

Solution

The hides are sprayed with a 10% solution of sodium sulphide, then fleshed and split. They are then sprayed with a $NaClO_2$ solution to remove any remaining Na_2S. This procedure allows 80% - 90% of the offal to be removed from the hides before they are treated with lime for unhairing, and opens them up more fully than conventional methods. The hides are not subject to swelling or chemical changes, and processing time is significantly reduced.

Raising the processing temperature to +40°C allows the hides to take up almost all of the chrome used in the tanning process. The fluid and sludge are treated with HCl and then passed through two sodium hydroxide columns, which absorb the resulting hydrogen sulphide. The recovered NaHS is then treated with NaOH to convert it back to Na_2S, which can then be recycled to the unhairing process. The remaining hair pulp can be filtered and used as a slow-acting nitrogen fertilizer or dried and powdered for use as a source of protein.

Benefits

- The quantity of chrome required is reduced by one-third, and most of this can be recycled because it does not become contaminated with sodium sulphide.

- The rate of sulphide recovery is approximately 75%.

- The cost of incorporating this process into a new tannery is 50% higher than that of a conventional system, but process efficiency and waste treatment are improved, costs for process chemicals and water are reduced, and waste disposal charges are eliminated.

For More Information...

Contact:	Blue Side Company St. Joseph, Missouri U.S.A.	References:	45, 50

4.2 GRANITE STATE LEATHERS (Nashua, New Hampshire)

Substantial Chrome Reduction Using Baychrome System

Background

Granite State, like most tanneries, had a substantial chrome waste problem.

Solution

The company changed its tanning system to use improved low-float drums and a new tanning agent, Baychrome 2403. In regular tanning, 1.7-2.0% Cr_2O_3 (based on white weight) is added after soaking and pickling. The new system requires a hide penetration of 0.9-1.0% of regular chrome liquor (38% basic), followed by the addition of the remaining Cr_2O_3 (0.3-0.35%) in the form of Baychrome 2403. Lengthening the running time and adding a small amount of neutralizing agent increases the chrome exhaustion rate from 80% to between 90% and 95%.

Process modifications included equipping the large tanning vessels with 84 hp motors so the low floats would tan through the heavy parts of the hide. Retanning and colouring operations had to undergo some changes because of the higher pH of the Baychrome tanning process and the degreasing effect of the relatively high end temperature (140°F) of the process. With these changes, the leather produced is equal in quality to that produced using a conventional system.

With the Baychrome process, chromium in the effluent is reduced by two-thirds. Spent chrome precipitates out because of the alkalinity of the wastewater. Previously, the plant had to treat its spent tanning baths with lime to precipitate out the chrome sludge.

Benefits

- The concentration of chrome oxide in the wastewaters has been reduced from about 10 ppm to less than 1 ppm. The need for chrome retanning has been eliminated because chrome retention in the first tanning wash is ten times better.
- In 1981, savings were estimated at $40,000-$50,000 per year.

For More Information...

Contact:	Granite State Leathers Nashua, NH	Reference:	47

4.3 GEBHARDT-VOGEL TANNING COMPANY (Milwaukee, Wisconsin)

Direct Chrome Recycling Makes Economic Sense

Background

Gebhardt-Vogel was under no regulatory pressure, but wanted to reduce raw material costs for its operation, which processes 12,000 sides each week.

Solution

The company began direct chrome recycling in April 1975. The exhaust chrome liquor is pumped from the tanning drums through a hydrasieve into one of two 3,900-gallon storage tanks. One tank has sufficient capacity to handle the spent bath from the firm's six hide processors. The second tank allows for an extra day's storage time and gives the liquor time to cool.

This simple system -- tanks, sieve, piping and pumps -- cost $35,000 (1975 US$). Maintenance is restricted to draining the system once a week and flushing out the buildup of natural grease and chrome soap with several thousand gallons of warm water.

Benefits

- Salt usage is cut from the standard 5.7% to 3% and there are also savings in sodium formate, sulphuric acid and chrome. In 1979, these savings were estimated at $76,550.

- Chrome in the plant's effluent was reduced by 70%.

For More Information...

Contact:	Gebhart-Vogel Tanning Company Milwaukee, Wisconsin	Reference: 46

TECHNIQUES

4.4 Acid-Sulphite Curing Process

A technique which eliminates the need for salt in curing hides has been successfully tested at the Eastern Regional Research Center in Pennsylvania. A mixture of acetic acid and sodium sulphite is used, and hides which have been soaked in this solution for ten minutes remain in good condition for up to one month. The technique is therefore suitable only for small operations with a rapid turnover of hides. However, the salt content in the wastewater from the tannery is reduced by 97%.

Contact: Eastern Regional Research Center
Wyndmoor, Pennsylvania.
Reference: 44

4.5 Producing New Leather Fibre Product From Leather Trimmings

The Centre Technique de Cuir in Lyon, France has developed a synthetic leather product, known as Dermonat™, from waste leather fibres.

The production process involves granulation, defibrillation and mechanical "knitting" of the leather fibres, which are mixed with synthetic fibres in a 2:1 ratio, producing a nonwoven material. This is dyed and treated to minimize surface abrasion and fraying, but retains the flexibility and durability of natural leather. The material is useful for sportswear, linings and seat covers.

Unlike other techniques, this process does not depend upon polymer-binding agents, which interfere with the absorbency and flexibility of the leather fibres. The equipment is available in modular form at reasonable cost. Lincrusta-Sangiar has been producing the material commercially since 1978.

Contact: Centre Technique de Cuir
Lyon, France.
Reference: 48

4.6 Recovery of Grease and Proteins

The CTC has also designed a unit to recover the fatty components and collagens from the fleshings of hides. Collagen fibres are useful for making filtering and absorbing materials, and trimmings can be used for a variety of purposes, including animal feed, sutures and edible casings for food products.

The waste is ground and mixed with steam and acid to neutralize the collagen and separate the grease from the proteins. The proteins are centifuged before being dried and ground for use as animal feed supplement. The remaining material is centrifuged again to separate the grease, which can be used in the manufacture of soaps and detergents. CTC's pilot plant processes 1.5 tons of waste per hour, recovering 1500 L of wastewater and producing 100-150 kg of protein meal and 140-160 kg of reusable grease.

Contact: Centre Technique de Cuir
Lyon, France.
Reference: 44

4.7 Use of Tannery Sludge to Make High-Nitrogen Fertilizer

Even with improved techniques for recovering fats and proteins from tannery wastes, a certain amount of sludge will remain. A number of centres are investigating the potential value of this sludge as an agricultural fertilizer. A Polish research group has experimented with a technique which involves adding milk of lime to the wastewater to make it alkaline, then adding ferrous or aluminum sulphate to coagulate it. The mixture is dewatered, leaving a sludge containing 17% dry matter. The sludge is partially fermented and composted and, when supplemented with minerals, can be applied directly to cropland as fertilizer.

Researchers at Thorsteinson Laboratory Inc. in the United States have studied the economics of producing nitrogen fertilizers from tannery sludge. A tannery working 100,000 pounds of hides per day produces 20,000 pounds of sludge. Dried fertilizer could be produced for $25 per ton (1982 US costs) if the elimination of disposal fees is taken into account. This compares favourably with a commercial price at that time of $32 per ton. The production of a high-nitrogen fertilizer could therefore prove to be a profitable sideline for a tannery.

Reference: 49

5.0 LUMBER AND WOOD PRODUCTS

The lumber and wood products industry is a major employer in Canada. Sawmills are not a major source of hazardous wastes, but sludges and sediments from tank bottoms and waste treatment, mixed alkaline and acid solutions and nonhalogenated solvents nevertheless constitute important waste streams from this sector. This sector also produces large volumes of wood wastes which constitute a disposal problem of some magnitude.

Increasingly tough world markets make it all the more important for the industry to reduce waste and improve efficiency wherever possible. If the state of the literature is any indication, however, there is a need for more activity in this area and more documentation of successful approaches that can be used to strengthen the industry's competitiveness by reducing input and treatment costs through waste reduction. Most of the examples in the literature involve basic "housekeeping" practices; there seems to be a low level of interest in reduction and recycling.

In recent years, there has been growing concern about toxic emissions from some of the products of this industry as well as from the plants themselves. Particleboards and plywoods have been found to "offgas" formaldehyde, which can pose indoor air quality problems. As the case of Medallion Kitchens (example 5.3) illustrates, the industry in the United States is taking steps to reduce this hazard.

CASE STUDIES

5.1 NEWFOUNDLAND HARDWOOD LTD. (Clarenville, Nfld.)

Reducing Sulphur Emissions and Saving Fuel

Background

This company was using an oil-burning heating system to produce steam for its asphalt and creosote plant. Fuel for the system was expensive, and sulphur-containing emissions contributed to atmospheric pollution.

Solution

A 300 hp Northfab wood-fired boiler was installed to replace oil-burning equipment. The system consists of a 16 ft by 12 ft boiler, a grit collector (with a 20 hp fan, grit bin, platform and accessories), a 35 ft chimney and a stoker (screw type with a 2 hp motor, a 2 hp F.D. fan, and a 2 hp fuel metering screw). It burns 7,900 tons of green wood chips annually. The chips are supplied by a local supplier for about $30/ton.

Benefits

- The Northfab has cut sulphur emissions from the plant considerably, since wood contains very little sulphur.

- The system reaches maximum capacity in one-sixth of the time required by the oil-fired boiler.

- 1.36 million litres of oil/year are replaced for a net saving of $118,800. Capital costs of the system were $587,500; simple payback was slightly under five years.

For More Information...

Contact: Newfoundland Hardwoods Ltd.
Clarenville, Newfoundland.

Reference: 56

OTHER EXAMPLES

5.2 GEORGIA PACIFIC CORPORATION (Oregon)

In order to reduce the pitch content of the exhaust air from the drying process in its plywood veneer manufacturing plant, this company installed a new scrubber system. Pitch is collected and reduced to a liquid with the same Btu rating as No. 6 fuel oil, and in quantities sufficient to replace 51,000 gallons of fuel each year. Not only does this system reduce airborne emissions to a level well within state requirements, but the water used in the seperation process contains almost no pitch and can therefore be recycled.

Contact: Georgia Pacific Corporation, Oregon. Reference: 51

5.3 MEDALLION KITCHENS OF MINNESOTA INC. (Waconia, Minnesota)

Minnesota's environmental regulations restrict the amount of formaldehyde which may be emitted from coated and uncoated wood products to 0.3 ppm. Emission levels from kitchen cabinets and wood furniture marketed in the state must be tested quarterly.

Medallion, which manufactures kitchen cabinets, bathroom vanities and shelving, uses two coats of Sherwin-Williams Sher-Wood Kemvar acid-catalyzed varnish over the wood stain. The varnish is reduced by 50% and applied as a sealer, then reduced by 25% for application as a topcoat. This treatment reduces emissions from the products to within permissible levels, as well as improving their appearance and resistance to moisture, chemicals and marring.

Contact: Medallion Kitchens of Minnesota Inc.
Waconia, Minnesota
Reference: 52

5.4 Recycling Effluent and Reducing Energy Costs in Plywood Manufacture

A French manufacturer of plywood boards uses a low-waste process in which effluents are concentrated and the resins recycled to the gluing operation. The process also recycles water used in debarking the wood.

For the production of 1 m^3 of plywood, this technique uses only 40 kg of water, 70 kg of resins and 0.75 GJ of energy, versus 340 kg of water, 75 kg of resins and 1.34 GJ of energy for standard plywood manufacturing, and produces virtually no waste.

In 1975, the cost of the system for a plant producing 65,000 m^3/year was estimated at FF 1,500,000. However, the plant would have had to install a treatment system for FF1,400,000 (plus operating costs of FF 2.20/m^3 of plywood) to meet environmental regulations had it continued to use the conventional process. Thus, savings in avoided treatment costs plus savings in energy (the new process uses about half the energy of the old) added up to a good investment.

Contact:
Ministère de l'environnement
Direction de la prévention des pollutions
14 Boulevard du Général Leclerc
92522 Neuilly-sur-Seine Cedex
France

Reference: 54

5.5 Closed-Circuit System Recycles Water

A French manufacturer of wood-fibre panels previously discharged the water used for transporting the fibres into the river, still carrying its content of fibres and soluble wood compounds. A closed-loop system was installed to recycle the water in order to meet local effluent regulations.

Water consumption was dramatically reduced; water is now needed only to make up process evaporation losses. Water consumption was cut from 30,000 L to 130 L per ton of panels manufactured, and the amount of wood required was reduced from 1.06 tons to 1 ton per ton of panels through recovery of wood waste.

The closed-circuit system reduced the amount of oxidizable and suspended matter in the water from 110 kg per ton to 0.8 kg per ton, and cost only 2.5 million francs to install (in 1968), compared with a cost of 5 million francs for standard treatment.

Contact:
Ministère de l'environnement
Direction de la prévention des pollutions
14 Boulevard du Général Leclerc
92522 Neuilly-sur-Seine Cedex
France

Reference: 55

6.0 MACHINERY

The machinery sector includes manufacturers of agricultural implements and various types of commercial and industrial equipment. In general, the sector is not a large generator of hazardous wastes. Typical wastes include waste oils, acid and alkaline solutions, paint wastes, halogenated and nonhalogenated solvents, and heavy metal sludges.

Important opportunities for reduction and recycling in this sector are solvent, oil and grease recovery and reduction in paint wastage. However, because the machinery industries are not major waste producers, there are few examples in the literature of waste reduction and recycling in this sector.

CASE STUDIES

6.1 EMERSON ELECTRIC COMPANY (Murphy, North Carolina)

Process and Management Changes Reduce Wastes and Costs

Background

Emerson Electric Company manufactures stationary power tools which require both metal finishing and painting operations. These include: an electrostatic paint system with a 7-stage metal pretreatment line that finishes 75,000 ft^2 of parts per day; a black penetrate and zinc electroplating line that finishes 10,000 lb of small parts per day; an aluminum die-casting facility that produces 30,000 lb of parts per day; a paint-stripping line that sirips paint from 1,000 ft^2 of parts per day; a two-stage small parts washer that cleans 3,000 lb of ware per day; a vibratory finishing line that processes 4,000 lb of parts per day; and a machining centre that contains 2,000 gallons of machine coolant and generates 10,000 lb of miscellaneous sludge and 75 gallons of spent chemicals per day.

The company had a number of specific waste management problems. Frequent oil spills at the scrap loading site and from the aluminum die-casting facility were contaminating the surrounding surface water and a nearby creek. Emerson was also having problems with unauthorized dumping of process chemicals and spent cleaners into the on-site water treatment system, which threw the system out of balance and reduced its efficiency. Excessive use of chlorinated solvents in degreasing operations also affected the system; half of the 1,800 lb of solvents used every month were finding their way into the waste treatment system.

Improper use of zinc chromates as an algicide in the evaporative cooling water systems was also a problem; 4 gal/min of blowdown containing zinc chromates were being discharged to the storm drain. And finally, poorly labelled chemical wastes presented a hazard to a nearby waterway; at one point, 20,000 lb of unidentified chemical wastes were being stored outside.

Solution

Emerson senior management led the way in implementing waste-reducing process changes and a comprehensive waste management system. In one year, a number of changes were made. An automated metal electroplating system was installed to replace the manual system, and the existing organic solvent-based paint system was replaced by a water-based anodic electro-static immersion paint system. An oil skimmer and ultrafiltration (UF) system were installed in the wastewater treatment system.

A number of improvements have resulted from this comprehensive waste management system. Unauthorized dumping of waste chemicals to the wastewater treatment plant was eliminated. Stored wastes were identified and labelled, and arrangements were made with appropriate hazardous waste companies to haul and treat them. Steam and alkaline detergent are now used for degreasing instead of chlorinated solvents. Algicides in the cooling tower system were reformulated to remove the zinc chromates and chlorinators were purchased for the cooling towers.

Emerson's waste management program is ongoing, and is managed by an in-plant process engineer. Process technicians maintain daily log sheets and all plant personnel have designated responsibilities in the program. The company also maintains an incentive awards program to encourage new ideas for cost savings or for the development of new products.

Benefits

- Plating Operation: Plating acid, caustic and oil wastes were reduced from 450 to 360 lb/day. Annual productivity increased by $200,000 and system downtime decreased from 8% to 4%. Chemical consumption decreased by 25%, resulting in an annual reduction of $8,000 in raw material costs. Water costs were reduced by $1,100/year and treatment costs for the water used in the plating operation were reduced by 25%. Annual savings in personnel and maintenance costs total $35,000; worker exposure to acids and caustics has been eliminated. Payback was 1.1 years.

- Paint System: The process generates only 150 lb/day of nonreactive solvent; 3,000 lb/day of aromatic chlorinated solvent wastes were eliminated and paint solid wastes were reduced from 70 to 2 lb/day. The quality of the paint application has been greatly improved and annual productivity is reported to have increased by $1,000,000. Downtime decreased from 3% to 1%. Since the water-based system allows 99.5% recovery and reuse of paint, raw material costs for paint have decreased by $600,000/year. Personnel and maintenance costs were reduced by 40% and worker exposure to organic paint solvents has been eliminated. Payback was 1.1 years.

- Oil Skimmer and UF System: Oil worth $8,000/year and 2,500 gal/month of reusable alkaline cleaning solution worth $3,000/year are recovered. About 370 lb/month of BOD are removed and water treatment costs have been cut by $10,000. Payback was 2 years.

- Degreasing: Chlorinated waste solvents were reduced from 900 to 180 lb/month.

- Cooling: Zinc chromate emissions were eliminated.

For More Information...

Contact:
Layton Schuh
Emerson Electric Company
Special Products Division
Murphy, North Carolina
28209 U.S.A.
(704) 837-5101

Reference: 63

OTHER EXAMPLES

6.2 DEERE AND COMPANY (Moline, Illinois)

In 1980, this manufacturer of farm and construction equipment formed a Hazardous Waste Task Force, comprised of employees from all levels, to improve waste management. Since then, Deere has reduced its hazardous waste disposal requirements by 80%. A proprietary high-tech liquid waste treatment facility produces a nonhazardous sludge; solvent reclamation is contracted out, and waste audits of each unit of the operation are carried out on a continuing basis.

The company invested $1,900,000 in the waste treatment facility, which can treat more than 2 million gal/year of hazardous wastes, including: electroplating sludges, spent electroplating baths, painting wastes, caustic paint-stripping wastes, kolene sludge from casting cleaning and miscellaneous acid and alkaline wastes. Also, oil can be reclaimed from 1.38 million gal/year of waste oils and oil-water mixtures. Waste disposal costs have been reduced by $230,000/year. Savings due to reuse of oil were not provided, but the payback period was reported to be 2.5 years.

Contact:	Mike McGuire Deere and Company Moline, Illinois	Reference: 62

6.3 HALSTEAD INDUSTRIES (Scottsboro, Alabama)

Halstead Industries produces custom-made heat-transfer equipment. The operation frequently involves degreasing large and unwieldy metal coils that sometimes extend more than 20 feet. The company uses an Econ-O-Solv carbon adsorption system along with a unique push-pull exhaust system to conduct solvent-laden air to the carbon adsorption unit.

Since the system was installed, trichloroethylene concentrations in the air have dropped to 25 ppm, well within regulatory limits. Savings from regulatory compliance more than pay for the $25,000/year required for solvents.

Contact:	Halstead Industries Scottsboro, Alabama	Reference: 59

6.4 MOYER DIEBEL (Jordan, Ontario)

This manufacturer of vending machines uses an automated powder coating process in its small paint line. It was installed in the early 1980s when the company was upgrading the paint line. Moyer Diebel paid $280,000 for its new powder line (manufactured by Interrad International), about $5,000 less than the cost of an equivalent liquid paint line.

Operating costs of the powder system are about 15% lower than for a conventional system. Moyer Diebel found that the powder coating sticks better and requires less cleaning. As a result, the company was able to reduce its 4-stage prewash system to 3 stages. Only 40-50% of the powder sprayed stays on the target object, but an efficient overspray recycle system ensures that 95-99% of the 5,000 lb of powder used each month is actually used for coating. Thus, the company does not accumulate paint sludge wastes. The powder line also uses about 35% less energy than a conventional system.

Contact:
G. Evans
Manufacturing Manager
Moyer Diebel
Jordan, Ontario
(416) 562-4195

References: 57, 61

6.5 SEALED POWER CORPORATION (Muskegon, Michigan)

This company manufactures piston rings. Installing Detrex freeboard chillers on seven of their degreasers reduced solvent use dramatically; the solvent concentration above the chiller units fell to an average of 55 ppm, well below prescribed limits. In 1981, it was reported that the company monitored the performance of two of the chillers and projected savings from those two units alone at $17,668/year.

Contact:
Sealed Power Corporation
Muskegon, Michigan

Reference: 58

6.6 "Green" Paints Use Less Solvent

Green Paints of Sheffield, England has developed a new range of paints for use on small pieces of machinery. The paints are made with recently-developed American synthetic alkyd resins made from vegetable matter. The Green paints, which are available in a range of colours, have less than 20% of the organic solvent content of normal industrial paints, and thus solvent vapours from painting operations are greatly reduced. The paints are reported to be available at a competitive price.

Contact:
Alan Beaven
Green Paints
Sheffield, England
(0246) 432193

Reference: 64

6.7 Dry Process for Hardening Spinning Rings

A French technique for hardening spinning rings eliminates the use of cyanurated salts. The salts are conventionally used to bring the parts to the desired temperature (840°C - 860°C), after which the parts are cooled in an oil bath and rinsed in water. In the French technique, baskets containing parts to be hardened are dipped into a fluidized bath of nitrogen and corundum particles at a temperature between 840°C and 860°C. The baskets are then dipped into another fluidized bath at 50°C. Corundum left on the parts is recovered and recycled.

The French Ministry of the Environment provided the following comparison between this technique and the conventional technique. For the production of 1,000 spinning rings, the low-waste technique requires 0.4 kg of corundum, 25 m^3 of nitrogen and 0.63 GJ of electricity. The standard technology requires 6 kg of cyanide, 3 m^3 of water and 1.26 GJ of gas. The low-waste technology produces virtually no waste, except for some dust. The standard technology produces used cyanurated salts, oil fumes and highly basic water (3.5 m^3 for 1,000 rings).

In 1979, investment required for the low-waste technology was estimated at FF 185,000 for 300,000 hardened rings per annum. Investment for the standard technology was estimated at FF 150,000 plus about FF 160,000 for a treatment plant for the cyanurated salts. The operating costs of the low-waste technology were estimated to be 60% of those of the standard technology (excluding treatment plant operating costs).

Contact:
Ministère de l'environnement
Direction de la prévention des pollutions
14 Boulevard du Général Leclerc
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France

Reference: 60

7.0 PAPER AND ALLIED PRODUCTS

The paper and allied products industry is a major employer in Canada and an important generator of hazardous wastes. Typical hazardous wastes include halogenated and nonhalogenated solvents, heavy metal sludges, acid sludges, waste oils, tank bottom sediments, resins and inks. Recovery and recycling opportunities include separation of waste streams, regeneration of spent acid, solvent recovery, reuse of waste inks and dyes, and process changes.

The pulp and paper industry has come under considerable regulatory pressure, and as a result, many companies are actively engaged in reducing and recycling wastes. There are a number of examples in the literature of waste management in Canadian companies. A main concern appears to be wood shortages, and many Canadian waste reduction programs are aimed at utilizing the maximum amount of fibre and phasing out fibre-inefficient chemical pulping processes.

CASE STUDIES

7.1 CANADIAN INTERNATIONAL PAPER COMPANY (Gatineau, Quebec)

SCMP Process Yields Superior Pulp and Reduces Pollution

Background

The increasing cost of kraft paper forced this newsprint mill to seek a way of reducing its consumption of this material. Conventional mechanical pulping techniques, however, yielded a pulp of inadequate strength.

Solution

A chemical-mechanical pulping process, Sulphonated Chemi-Mechanical Pulp (SCMP), was developed and tested for three years before a full-scale 380-tonnes-per-day plant was constructed at the mill in Gatineau, Quebec. The plant has been in operation since mid-1978.

Washed, pre-screened wood chips are cooked for 30-45 minutes at 140°C with a 12% sodium sulphite solution. The high sodium sulphite concentration maximizes the sulphonation of the lignin and much of the sodium sulphite can be recovered from the spent cooking solution and reused. The chips are pressed and refined. The liquors are combined and sodium hydroxide is added before they are passed through an absorption tower to remove sulphur dioxide. The liquor, once again at a concentration of 12% sodium sulphite, is recycled to the digester.

Benefits

- The preliminary sulphonation step ensures that the pulp obtained from the SCMP process compares favourably with newsprint pulps from other thermo-mechanical processes in strength, yield, brightness and opacity.

- This process can accommodate such raw materials as sawmill residues, which helps to conserve high-quality wood stocks. Up to 40% hardwoods, such as poplar, can be used in the pulp, which conserves softwoods.

- While restricted to newsprint production at present, the process is of potential value in the production of tissue products, packing materials and coated publication paper.

- Sulphite pulp can be eliminated completely, which increases pulp yield and reduces BOD in the discharge. The use of alkaline liquor eliminates sulphur dioxide emissions, reducing atmospheric pollution.

- Improved separation of the fibres during pulping increases the yield from this process and reduces the quantity of fibres lost in the discharge. This means a reduction in BOD. Overall BOD in the discharge from the mill dropped from 176 tonnes per day to 49 tonnes per day.

For More Information...

Contact:	Canadian International Paper Co. Gatineau, Quebec	Reference: 67

7.2 CONSOLIDATED-BATHURST INC.
(Shawinigan, Quebec and Bathurst, New Brunswick)

Modernization Improves Pulp Quality and Cuts Discharge

Background

Consolidated Bathurst made the decision to replace sulphite pulping in order to meet stricter government effluent discharge regulations. For each tonne of paper produced, a mill is allowed to discharge 45 kg of BOD_5, and this limit will be reduced still further in the future. The challenge is to maintain or improve product quality while meeting these requirements.

Solution

The company has begun a switch to chemi-thermo-mechanical pulping (CTMP) at its newsprint mill in Shawinigan, Quebec. The conversion will be carried out in two stages: the first phase, now under construction at a cost of $64 million, will allow two-thirds (600 tpd) of pulp production to be provided by CTMP. The system does not incorporate reject refiners, since any rejected fibre is returned to the secondary refiner.

The company is also carrying out a modernization and expansion program at its corrugated medium paper mill in Bathurst, New Brunswick. The first phase involved the installation of a chemi-thermo-mechanical softwood pulping machine at a cost of $106 million. The company is currently completing the addition of a bleaching unit, and the last phase of the program will be the installation of a new corrugated medium paper machine which will use semi-chemical hardwood pulp. Federal-provincial grants will provide $26 million out of the anticipated $257 million total for the program.

Benefits

- Replacing sulphite pulp with CTMP is expected to increase overall yield at the Shawinigan mill by 6.25% and improve product quality. Energy consumption at the mill is expected to decrease by 13.5% through heat recovery.

- Sulphite wastes and BOD loadings at the Shawinigan mill are considerably reduced.

- Installation of the new corrugated medium paper machine in Bathurst will improve environmental performance.

For More Information...

Contact:	Consolidated Bathurst Inc. Belgo Division Shawinigan, Quebec	Consolidated Bathurst Inc. Bathurst, N.B.

References: 71, 75

7.3 EDDY FOREST PRODUCTS LTD (Espanola, Ontario)

Modernization Program Improves Pulp Quality and Minimizes Effluent

Background

This pulp mill, which was established in the mid-1940s, pioneered commercial oxygen bleaching of softwood kraft pulp in 1977. Use of the Modo-cil-oxygen/alkali bleaching process has reduced chlorine consumption by well over 50%. However, the mill was in need of modernization to enable it to meet environmental guidelines and improve product quality in order to remain competitive.

Solution

The company embarked upon a $230-million modernization and expansion project. Most equipment was either replaced or upgraded, increasing the capacity of chip handling, digester, bleach plant, recovery boiler and evaporator. A new black-liquor evaporation system, which can produce black liquor up to 75% solids, and a new low-odour recovery boiler have been installed.

Flue gases are processed through a high-efficiency electrostatic precipitator, and an odour-control system designed by Lundberg-Allen allows noncondensible odorous sulphur gases to be collected and incinerated. Foul condensates from the digestor and evaporator areas are steam-stripped to remove odorous sulphur gases and methanol, which are also incinerated. A Dorr Oliver causticizing system has also been installed. A secondary water-treatment system with two settling basins will enable the company to meet government water pollution regulations. It is anticipated that settled solids will require removal to a landfill site on a yearly basis.

A new bleaching line, installed in 1981, consists of two 3-stage lines, each preceded by an oxygen and hot chlorination stage. The unbleached stock is pressed and then oxidized white liquor is added before it is fed into the oxygen reactor. The pulp is washed and mixed with chlorine. Effluent is recycled through the system.

Benefits

- Oxygen bleaching produces a faster beating pulp with lower viscosity and similar strength properties. The technique also allows special pulps to be produced to order. It has reduced chlorine consumption in the bleach plant by well over 50% and reduced bleaching costs by 10-15%.

- Oxygen bleaching has led to a 50% reduction in bleach plant effluent BOD and has minimized corrosion and reduced the toxicity of the discharge.

- The plant modifications have increased bleaching capacity to 1000 tpd.

- The secondary water-treatment system has decreased BOD levels by almost 80% in winter and approximately 95% in summer. The effluent meets federal toxicity standards.

- The new recovery boiler system has reduced atmospheric emissions by 88% for particulates and 99% for sulphur gases.

For More Information...

Contact: Eddy Forest Products Ltd.
Espanola, Ontario

References: 68, 70

7.4 KRUGER INC. (Bromptonville, Quebec)

Recovering Whitewater Improves Waste Management

Background

A series of modest modifications to this newsprint mill, undertaken primarily to conserve energy, have also improved the management of waste. Lean whitewater from the company's three paper machine presses was previously discharged to the sewer because it contained felt fibres. Clean whitewater from two disc filters was also sent to the sewer.

Solution

In order to recover the lean whitewater, it is collected by gravity flow in a reservoir beneath the paper machines. It is then pumped through a Sweco filter, from where the accepts are returned to the lean whitewater chest and the rejects, which comprise 10% of total flow, are eventually sent to the clarifier. Recovered whitewater is used mainly for dilution of stock.

Clear whitewater is now used instead of heated freshwater on the paper machine showers. From the seal pit the whitewater is pumped through six filters designed by the company.

Benefits

- Recovery of whitewater has considerably reduced the quantity requiring discharge to the sewer. Recovery of the lean whitewater has led to savings of $500,000 per year and reduced the amount of fibre reaching the river through the sewer.

- The amount of fibre recovered is 1.8 tonnes per day, which represents an annual value of $80,000.

For More Information...

Contact:	Kruger Inc. Bromptonville, Quebec.	Reference: 76

7.5 NORTHWOOD PULP AND PAPER LTD (Prince George, B.C.)

Modernized Equipment Reduces Bleaching Effluent and Particulate Emissions

Background

This pulp mill, which produces 680 tpd of bleached sulphite pulp, was seeking ways of improving waste management.

Solution

In order to reduce the volume of effluent, a dynamic bleaching process, using equipment supplied by Kamyr, was installed. Four separate bleaching stages occur in a single tower. Bleaching chemicals are displaced through the mat of pulp as it moves upwards.

A Munters particulate removal unit was installed in 1982 to reduce particulate emissions from the smelt dissolving stack. The unit cost $40,000 to install, which is low compared with the installation cost of $230,000 for a Venturi scrubber. The unit comprises a number of multiangular components arranged in parallel to form modules which are arranged in the gas stream. They act as mist eliminators through impaction. The particulates are wetted and captured and the collected water droplets are directed back down the stack.

Benefits

- The dynamic bleaching process has reduced the volume of bleaching effluent to about 15 m^3/tonne of pulp, and doubled bleaching capacity.

- The Munters system keeps particulate emissions below 0.2 kg/tonne (the level set by the company as its goal), provided the particulate-laden gas stream is showered evenly with a fairly coarse spray, and that the plates are clean.

- No energy is required, which represents a cost saving, inasmuch as the annual energy costs for a Venturi scrubber would have been $15,000. (The removal efficiency of the Munters system is 90% of that of the Venturi system.)

For More Information...

Contact:	Northwood Pulp and Paper Ltd Prince George, B.C.	References: 68, 74, 78

OTHER EXAMPLES

7.6 ABITIBI-PRICE INC. (Smooth Rock Falls and Thunder Bay, Ontario)

In order to comply with provincial controls on the amount of effluent entering Lake Superior, the Fort William division of Abitibi-Price in Thunder Bay installed a sulphonated chemi-mechanical pulp (SCMP) plant in 1980 at a cost of $30 million. The installation has eliminated sulphite effluent, while maintaining the fibre strength properties of sulphite pulp. Yield has been increased to 90%, compared with 65-70% for the sulphite process. The sulphite operation was gradually phased out. The company finds that the process lends itself to continuous operation, in contrast to a sulphite mill, which is a batch operation.

Abitibi-Price has installed a Teller scrubber system at its mill in Smooth Rock Falls to reduce particulate and hydrogen sulphide emissions from the recovery boiler. This scrubber system consists of a Roy-Lin vVenturi which wets the particles so that they can be collected from the flue gas by a Crossflow Nucleation scrubber.

A liquid consisting of an alkaline suspension of powdered activated carbon trickles downwards through packing in the scrubber, thus ensuring gas/liquid contact. Hydrogen sulphide is absorbed by the alkaline solution and then reacts with caustic and oxygen to produce sodium thiosulphate. The scrubbing liquor is recycled to the scrubber. Sulphur dioxide is also recovered in the form of sodium sulphate.

The gas is then washed and heat is recovered through direct contact with water. The saving in energy is such that the cost of the system can be recouped in three years. This process removes 96.4% of the hydrogen sulphide and all the sulphur dioxide. Particulate emissions have been reduced from a range of 200 to 500 $\mu g/m^3$ to 126 $\mu g/m^3$.

Contact:

Abitibi-Price Inc.
Fort William Division
Thunder Bay, Ontario

Abitibi-Price Inc.
Smooth Rock Falls, Ontario

References: 65, 67, 68, 69, 77

7.7 BOISE CASCADE CANADA LTD (Fort Frances, Ontario)

A number of noncondensible gases are emitted from pulp mill digesters, turpentine recovery systems and evaporators and must be incinerated. These gases include hydrogen sulphide, methyl mercaptan, dimethyl sulphide and dimethyl disulphide, whch are known collectively as total reduced sulphur (TRS) gases. TRS gases are highly toxic, corrosive and explosive when mixed wth air. Organic compounds, such as turpentine vapour and methanol, are also present, and these vapours are also explosive.

In a conventional system, these gases are collected in a common pipe and blown by a fan to the kiln. A forced-draft fan introduces them into the kiln. This system has a number of drawbacks, including the potential for spark-induced fires and explosions, corrosion of the fans and odour problems.

Boise Cascade installed a new system, developed in Sweden, in 1982. A steam ejector was installed to motivate the blow gases, injecting them directly into the kiln and bypassing the forced-draft fan. This eliminates ignition sources, such as sparks and hot spots, and prevents corrosion and leakage. A pressure control valve before the ejector ensures that the gases can be pulled through the system while excluding atmospheric air. This further reduces the potential for explosion.

The capital, operating and maintenance costs of the new system are similar to those of the conventional system. It is operating well and the odour level around the mill has decreased.

Contact:	Boise Cascade Canada Ltd. Fort Frances, Ont.	Reference:	66

7.8 ONTARIO PAPER COMPANY (Thorold, Ontario)

The Ontario Paper Company is solving the problem of replacing sulphite pulping by using a recycling approach. The company will modify a chemi-mechanical pulp machine to handle wood chips rejected by its own thermomechanical process. A new de-inking plant, using a dissolved air flotation tank rather than washing, will allow the company to recycle magazine paper as well as newsprint. The waste-paper recycling operation will handle about 180,000 tons per year.

Contact:	Ontario Paper Company, Thorold, Ont.	Reference:	73

7.9 TEMBEC INC. (Temiscaming, Quebec)

Babcock and Wilcox converted one of the coal-fired boilers at this pulp mill to use waste sulphite liquor at a cost of $32 million. The conversion, which was completed within 40 days in late 1980, was implemented for environmental reasons and in anticipation of considerable cost savings.

The liquor from the batch digesters is taken to a blow-pit, and then drawn off to a storage tank. Vapour compression evaporators increase the concentration to 49-50% solids, and the liquor is ready for use in the boiler. Operating problems are less significant than those encountered with coal firing. After three years of operation the savings approached $10 million per year.

Contact:	Tembec Inc., Temiscaming, Que.	Reference:	72

8.0 PETROLEUM AND COAL PRODUCTS

Companies in this sector produce a variety of refined petroleum and coal products, lubricating oils and greases. Typical hazardous wastes generated include alkaline sludges and solutions, spent catalysts, spent acids, oily clays, acid solutions, inorganic solids, waste oils, halogenated and nonhalogenated solvents, phenols and spent caustics. Recycle and reuse opportunities include separation of oil-water emulsified mixtures and regeneration of spent caustics and acids.

The Petroleum Association for the Conservation of the Canadian Environment (PACE) recently completed a report on waste management in the petroleum industry; this report was still being printed at the time this catalogue was written. The Canadian Petroleum Association (CPA) is also heavily involved in waste management research. Monenco, for example, is conducting a CPA-funded study to determine the best disposal method for gas plant sludges. In cooperation with the Environmental Protection Service, the CPA has prepared a video-taped waste management training program for oilfield operators, and the association also helped initiate a waste disposal training course that is taught by the Petroleum Industry Training Service.

Waste management is becoming a higher priority for the petroleum industry. Cost savings are being achieved in many areas of the oil industry by recycling steel drums, solvents, lubricants and drilling fluids. Companies are now tracking drums to ensure that they are recycled, and chemicals and lubricants are being bought in bulk whenever possible to avoid the use of drums altogether. Drums are a particular problem because up to 20 L of liquid can often remain in an "empty" drum; those that cannnot be recycled are sent to companies such as Vulcan Industrial Packaging of Edmonton for reconditioning.

A number of entrepreneurs such as Canadian Crude Separators of Calgary have set up oil reclamation facilities to recover saleable oil from wastes such as tank bottom sludges, sumps and spilled oil. The reclaimers often get paid both for the waste disposal service they provide and for delivering recovered oil to pipelines.

A technology that received considerable attention in the literature in the early 1980s was the Phillips Rerefined Oil Process (PROP), which used a combination of chemical demetallization and hydrotreating to rerefine waste oil into a base oil suitable for use in blending of motor oil and other lubricants. However, several Canadian companies that considered or tried this process found problems with it. Mohawk Oil Lubricants bought a PROP system but never installed it because there were too many problems with the design. Canadian Oil, a subsidiary of Shell Oil, actually installed the PROP system after making modifications to the design. Although there were commissioning and operation problems, the system is operating well and is currently producing half of the re-refined oils in Canada.

8.1 CHEVRON USA INC. (Louisville, Kentucky)

Using Improved Drum Washing System and Water-Based Paint Yields Savings

Background

Chevron's petroleum product warehouse in Louisville, KY includes a shipping drum reconditioning facility where used drums are cleaned and repainted for reuse. Prior cleaning practices generated 500 gal/day of a complex hazardous waste stream composed of caustic, oil, water and paint. This caustic rinsate did not meet the limits set by the local sewerage authority and had to be disposed of as a hazardous waste, costing the company $50,000 per year.

Paper filters collecting overspray from the solvent-based paint spraybooth also posed a disposal problem. In addition, the filters did not provide adequate air emission controls and additional measures were needed to reduce solvent emissions from the paint spraybooths. Employee exposure to the noise, caustic vapours and solvent paint base were described in a company report as unacceptable.

Solution

A state-of-the-art drum washing, reconditioning and painting system was installed. The system uses only high-pressure hot water to wash the drums. The oil is reclaimed and the water is reheated and reused. The small volume of water which is discharged to the local sewer system meets the wastewater discharge limitations.

The organic solvent-based paint was replaced with a water-based paint; a water-wall filtration system captures the overspray. The filtrate residue is nonhazardous.

Benefits

- Plant efficiency has been improved and plant capacity has increased by 700 drums per day.

- Reclaimed oil is sold to a recycler, netting Chevron a reported $12,000/year.

- Annual cost savings are reported to be: $25,000 in personnel costs; $6,800 in maintenance and other equipment costs; $13,400 in caustic and other chemical costs; $5,300 in paint costs; and $50,000 in avoided hazardous waste disposal charges.

- Payback on the new system is reported to be 3 years.

For More Information...

Contact: Steve Raetz
Chevron USA Inc.
Louisville, Kentucky
U.S.A.
(502) 566-5607

Reference: 82

8.2 DOME PETROLEUM LTD. (Lindbergh Oil Sands, Alberta)

Recycling of Oily Sand Wastes

Background

Heavy oil production from the Lindbergh Oil Sands area requires the disposal of oily sand waste products from the treatment facility that cleans the heavy oil. Historically, treaters were routinely desanded into desand pits, and a backhoe and trucks were then used to haul the waste to an "ecology pit". Ultimate disposal involved spreading the oily sand on surrounding roads.

The time and equipment involved in this procedure contributed significantly to higher operating costs. A particular concern was the fact that the volume of sand in the oil contributed to high wear and maintenance problems both in the treaters and in the associated sand handling equipment.

Solution

Dome developed an oily sand cleaning system to extract the sand waste by-product directly from the Enhanced Oil Recovery (EOR) heavy oil treatment process as early in the process as possible. Coincident with the design of the oily sand cleaning system, a Free Water Knock Out (FWKO) system was being added to the EOR emulsion treatment process to handle increased water volumes. Since this would be the first piece of process equipment to treat the EOR emulsion, it was modified to allow sand to be continuously extracted.

The sand drops out of the emulsion in the FWKO and is flushed to the bottom of the desand cone by the desand rings. The oily sand cleaning system pumps a sand slurry from the FWKO desand cone to a series of hydrocyclones where the lighter oil and water are separated from the heavier wet sand.

The oil and water overflow from the hydrocyclones is returned to the FWKO for continued treatment while the wet sand is processed over a dewatering screen to remove additional moisture. The clean sand product is collected in a hopper that is mounted on a steel structure high enough to allow a truck to drive underneath and collect a load through the sliding dump gate. No additional heavy equipment is required to load the truck. The clean sand is then trucked to a disposal site.

Benefits

- The system, which cost $200,000, paid back in less than one year.

- Annual savings total $325,000; the major savings are $30,000 in avoided fluid handling requirements, $25,000 in avoided desand pit cleaning, and $85,000 in avoided disposal costs.

- The system minimizes handling of the sand, requires less equipment for sand disposal, and eliminates the need for frequent cleaning of disposal equipment, as the sand is no longer oily.

- 392 m^3 of oil are recovered annually.

For More Information...

Contact: Ted Rolfvondenbaumen
Dome Petroleum Limited

Reference: 84

8.3 KUWAIT PETROLEUM (DENMARK) A/S (Skaelskor, Denmark)

Recovery of Gasoline Vapours

Background

In the process of transferring gasoline from bulk storage facilities into tank trucks for delivery, substantial quantities of gasoline vapour were being lost.

Solution

An innovative demonstration unit was installed at the Kuwait Petroleum facility in Skaelskor. The gasoline vapours are collected and treated in an absorption unit that uses a petroleum distillate as the absorption medium. The gasoline is split off from the absorption medium in a splitting unit and mixed with fresh gasoline. The petroleum distillate is recycled to a storage tank.

Benefits

- 90-96% of the gasoline vapour is recovered (approx. 425 m^3 liquid).
- In 1983, it was reported that a facility such as this, with sufficient capacity for an operation loading 250,000 m^3 of gasoline per year, would cost approximately US $265,000 - $315,000. Operating costs would be in the order of US $47,100 per year. The value of the recovered gasoline was put at US $187,000. Thus the payback would be under 2 years.

For More Information...

Contact: Technological Institute
Oil-Gas Offshore Section
Gregersensvej
DK - 2630 Taastrup
Denmark

Reference: 81

OTHER EXAMPLES

8.4 ABU DHABI MARINE OPERATIONS COMPANY (Abu Dhabi)

This company was reported several years ago to have installed three oil-water separators, manufactured by Fram Industrial, to recover oil from wastes of its wet crude oil treatment operation. The Fram separator, originally designed to treat oil-laden bilge water on ships, consists of a series of vertical and horizontal corrugated plates. Oil droplets coalesce and rise to the underside of the oleophilic polypropylene plates. Eventually, the oil passes through weep holes to the upper surface, where it is collected by a skimmer.

The filter is adapted to industrial situations where the solid content of wastewaters can be as high as 1000 ppm. A computer simulation program allows for a precise calibration of the plates to maximize recovery from a specific wastestream.

The three separators, which cost $500,000 installed, were expected to save $2 million annually when operating at full capacity.

Contact: Fram Industrial References: 79, 83

8.5 ESSO RESOURCES CANADA

Water recycling is a major feature of projects such as Esso's Cold Lake in-situ oilsands operation. If the contaminated water is not recycled, it has to be pumped down into deep wells. In addition to the actual costs of drilling and operation, deep-disposal wells require extensive geological studies to ensure that the water will never penetrate groundwater supplies. At Cold Lake, 78% of the water is now recycled, and bitumen is recovered from the waste pits at the plant.

Contact: Randall Gossen Reference: 80
Communications and Planning Department
Esso Resources Canada
Calgary, Alberta

8.6 SHELL CANADA

Shell is one of several petroleum companies using glass-fibre storage tanks in petroleum storage facilities. Unlike metal tanks, the glass-fibre tanks do not corrode, releasing oil into the air and groundwater. (Such oil leaks can pose a fire hazard as well as causing pollution). A Shell subsidiary manufactures the tanks. An 18,900 L tank cost about $4,700 in 1982, but transportation and installation costs apparently vary substantially.

Contact: Wilson Stark Industries Limited Reference: 85
Enviroglas Division
P.O. Box 1088
Belleville, Ont. K8N 5E8
(613) 966-7660

9.0 PRIMARY METALS

The primary metals sector comprises iron and steel mills as well as aluminum, copper and other metal smelting and refining operations. There are approximately 400 of these establishments in Canada, producing such hazardous wastes as heavy metal sludges, waste pickling liquor, acid solutions, caustic neutralization wastes, acid and alkaline solutions, waste oils, metal finishing sludges, halogenated and nonhalogenated solvents, inorganic solids and scrubber sludges.

There are many opportunities to recycle and reuse wastes in the primary metal industries, but there is little documentation in the literature of initiatives by Canadian companies.

CASE STUDIES

9.1 "BERZELIUS" METALLHUTTEN-GMBH (Duisburg, Germany)

A Cleaner, One-Step Technique for Smelting Lead

Background

The old-established technique for smelting lead is a two-step process. First, the galena concentrates are sintered to produce lead oxide, which is then converted to metallic lead in a blast furnace by reaction with coke. The gangue minerals, such as silica, lime and iron, are collected in the form of a fluid slag which can be separated from the molten metal. The lead is refined to extract copper, nickel, antimony and other valuable elements. The slag from the blast furnace is dumped and the waste gases, after being cleaned by scrubbers, baghouses and electrostatic precipitators, are sent to the stack.

Solution

The QSL process was developed to smelt lead sulphide concentrates and sulphate and mixed oxide-sulphate secondaries, including flue dusts, battery paste or lead-silver residues. Named for its three inventors, the technique has been used in a demonstration plant since late 1981. Continuous smelting occurs in a long horizontal cylinder. The sulphides are partially oxidized, forming metallic lead, lead oxide slag and sulphur dioxide gas. The slag runs continuously through the reduction zone of the reactor, where more metallic lead is recovered by reaction with a mixture of pulverized coal and air. The molten lead is tapped continuously.

The sulphur dioxide gas recovered from the raw material and the smelter fuel is cleaned and used to produce sulphuric acid and the flue dust is recycled.

Benefits

- This is a continuous, one-step process, with lower capital and operating costs than conventional smelting. The capital cost of a smelter capable of processing 100,000 tons of lead per year is given as DM 120-150 million for a conventional unit compared with DM 90-110 million for a QSL unit. Production costs per ton of lead are DM 385 for conventional smelting and DM 235 for processing by the QSL technique.

- Sulphur dioxide emissions are reduced by about 95%. The slag is safe for disposal.

- The process is cleaner, therefore working conditions are better.

For More Information...

Contact: "Berzelius" Metallhutten-Gesellschaft mbH   Reference: 92
4100 Duisburg 28
Postfach 28 11 80
Germany

9.2 BRITISH ALUMINIUM COMPANY (Gerrards Cross, England)

Cleaning and Degassing Liquid Aluminum Outside The Furnace

Background

Liquid aluminum contains hydrogen, which can form blisters when the metal is rolled to a thin sheet, and solid inclusions, which can cause defects in products manufactured from the aluminum. Existing methods of cleaning and degassing involve the use of chlorine and hexachlorethane, which can lead to fume-disposal problems, or nitrogen, which can add to the inclusions, or argon, which is expensive. These techniques involve treatment in the furnace and therefore have the disadvantage of requiring other operations to be curtailed for an hour or more while treatment is in progress.

Solution

This British company has developed a process of fumeless in-line degassing (FILD) of the liquid metal outside the furnace. The unit operates continuously, and without producing fumes, by treating the aluminum with nitrogen under a salt flux layer. The liquid metal then passes through an alumina ball bed to clean it further. This is an efficient technique which can be used to treat very dirty metal. The capital cost of the unit in 1980 was £20,000.

Benefits

- The advantages of this technique lie in the cost savings it affords. These arise from the avoidance of the need for fume treatment equipment, better use of furnaces, and lower cost than conventional treatments.

- Energy costs are also reduced, since there is no longer any need to interrupt operations, which requires the liquid metal to be held at operating temperature.

- Operating costs in 1980, based on treating 20,000 tonnes of metal per year, are reported to be £28,000. These compare very favourably with operating costs of £92,600 for hexachlorethane degassing.

- No special ventilation is required.

For More Information...

Contact: The British Aluminium Company plc
Technology Sales Group
Chalfont Park
Gerrards Cross
Buckinghamshire SL9 0QB
Great Britain

Reference: 89

9.3 KHD HUMBOLDT WEDAG AG (Cologne, Germany)

Regenerating Used Foundry Sand

Background

The cost of providing an adequate supply of high-quality foundry sand, particularly in countries without an indigenous supply, and the cost of disposing of large quantities of used sand are both increasing rapidly. Suitable ways of recovering and reusing the sand are needed. This involves removing the binder burned onto the quartz grains during the moulding process.

Pollution regulations governing waste gas emissions and the disposal of the sand have become more stringent, making conventional treatments less attractive. While a number of new processes have been developed, most are tailored to specific sand/binder systems and, in addition, have not proved to be cost-effective.

Solution

The German company KHD Humboldt Wedag operates a pilot plant in Cologne using its own multistage reconditioning and recycling technique. Sand discharged from the foundry is delivered by conveyor to a silo, where a permanent low-intensity magnetic separator removes iron, which otherwise would become sintered to the quartz grains during the subsequent thermal treatment. The remaining nonmagnetized portion is delivered to a fluidized-bed furnace consisting of a vertical, cylindrical brick-lined reaction chamber. A mixture of preheated combustion air and natural gas is admitted to fluidize the sand, which is heated to approximately 870°C, and the carbon is largely burned. A second reaction chamber above the fluidized bed ensures that the gases are held until they are completely burned.

The regenerated sand is then cooled to 30°C, first by direct injection of water and then in a water-operated indirect counter-current cooler. The heat removed from the sand is recycled to heat water for the foundry. The dust is filtered from the exhaust gas, which is then directed to the waste stack.

After this thermal treatment, the sand is cleaned in a counter-current impact mill to remove impurities. The grinding zone in the mill consists of two gas jets which accelerate the feed to a velocity of 30-40 m/s, and the resulting friction cleans the surface of the particles. The sand can then be returned to the foundry. The dust which accumulates in the furnace and the counter-current impact mill is collected and mixed with water or waste products from scrubbers in other parts of the foundry to form a sludge suitable for disposal. This process is reported to be very reliable, requiring little maintenance, and the regenerated sand is of similar quality to fresh sand.

Benefits

- A fluidized-bed furnace provides short, intensive thermal treatment.
- Prior separation of the magnetic particles enables the thermal process to recover better quality sand.
- The quantities of sand requiring disposal are reduced to one-quarter to one-fifth of those left after conventional treatment.
- The waste gas meets local emission standards.

- Based on a regeneration rate of five tons of sand per hour, operating costs are reported to be DM 532,333 per year, though this is reduced to DM 282,110 if heat is recovered. The cost of providing and disposing of sand without regeneration is DM 115.00/ton; while the regeneration plant lowers this cost to DM 63.33, representing a saving of DM 47.67/ton. Capital costs are given as DM 5,480,000.

- Tests are underway to investigate whether the by-products can be marketed for use in other processes, which would further reduce the need for disposal.

For More Information...

Contact: H. Bauer
KHD Humboldt Wedag AG
Abt. IH-MV 3
Postfach 10 27 29
D 4630 Bochum 1
West Germany

Reference: 93

9.4 NORANDA INC. (Noranda, Quebec)

Continuous Copper Smelting Process Cuts Down Emissions

Background

Noranda's Horne smelter has been processing copper since 1927, and since the 1940s has been accommodating copper scrap. Conventional copper smelting occurs in a reverberatory furnace and reactor, where the concentrates or scrap are melted at 1200°C to produce a matte composed of copper and a slag containing the impurities. The matte is transferred to converters, where most of the impurities are removed through oxidation and scorification. The copper is purified by reheating in anode furnaces. Particulates, sulphur dioxide and dust are released into the atmosphere during smelting operations.

Solution

The Noranda Process Continuous smelter was brought into operation in 1973. Continuous smelting eliminates the first phase of the conventional refining process. The copper is processed in a single, cylindrical refractory-lined reactor. The molten matte is vigorously agitated by the injection of air through tuyeres. The heat released by the oxidation of iron and combustible components melts the scrap, and any excess heat is used to melt other feed materials. Because the scrap is fed at a steady rate, the process parameters, such as the addition of flux and fuel and the volume of air blown, can be adjusted to ensure a consistent operation.

After being refined to 76%, the matte is transferred to the conventional converters. Product quality is reported to be maintained. This smelter has a greater capacity to take in reverts from other smelting operations and to treat wet or fine scraps more readily than a reverberatory furnace. It is now one of the major consumers of scrap in North America. The smelter extracts nearly 220,000 tonnes of copper per year from approximately 860,000 tonnes of smelted concentrate.

Benefits

- The single furnace process allows exhaust gases to be readily treated to remove particulates and sulphur dioxide. Dust emission is significantly reduced.

- Capital, operating and energy costs are reported to be lower than those which would be incurred by retrofitting a reverberatory furnace with sulphur dioxide controls.

- Continuous operation minimizes heat loss during transfer of material.

For More Information...

Contact: Noranda Inc.
Noranda, Quebec

References: 94, 97

OTHER EXAMPLES

9.5 ALUMINUM COMPANY OF AMERICA

This company has developed several pollution-abatement techniques for aluminum smelting and refining operations. The first represents a fundamental change in smelting technology, involving the production of aluminum chloride, which is reduced to aluminum and chlorine. The aluminum is withdrawn and the chlorine is recycled in a closed system. This method, which took 15 years to develop and cost $25 million, is more efficient than conventional smelting systems and has the added advantage of eliminating fluoride emissions.

The second technique, known as Process 39, is a dry-scrubbing system for controlling fluoride emissions from aluminum smelting pots. By capturing and recycling more than 99% of the total fluoride content in the fumes, fluoride requirements are reduced by more than 50%. This process is also expected to conserve 80 million gallons of water each day.

Thirdly, a process for controlling carbon-baking furnace emissions also has the benefit of avoiding the need for large quantities of water and extensive water-treatment facilities.

Contact: Aluminum Company of America Reference: 86

9.6 BRUNSWICK SMELTING (Belledune, New Brunswick)

The amount of lead reaching the air from this smelting operation was a cause for concern for environmental and employee health reasons. The lead enters the air in the fumes from the furnaces, and also in the form of dust produced during processing. Prolonged exposure leads to high levels of lead in the blood, and may have severe health effects.

Between 1968 and 1982, the company spent $15 million on engineering controls, including a five-fold increase in ventilation throughout the plant and installation of baghouses to collect the lead dust, as well as roof fans and exhaust hoods. Many conveyors and processes were enclosed. The company also implemented a number of other measures: lead fumes and dust are monitored in the smelter, and employee blood-lead levels are checked every month.

Employees are encouraged to improve hygiene, and are required to wear respirators if the lead level in the air rises above 0.15 mg/m^3. As a result, the cleanliness of the air has improved significantly, and average blood-lead levels have fallen from 59 µg/100 ml in 1975 to 37.5 µg/100 ml in 1984. The number of employees with a blood-lead level above the threshold established by the company for relocating an employee to a low-lead work area dropped from 175 in 1972 to 4 in 1984.

Contact: Brunswick Smelting
Belledune, New Brunswick
Reference: 87

9.7 DOFASCO INC. (Hamilton, Ontario)

Gas produced during coke-making operations contains a number of impurities, including ammonia, hydrogen sulphide and hydrogen cyanide. These must be removed before the gas is distributed for use as a fuel.

Hydrogen sulphide is removed by oxidation to elemental sulphur. However, the hydrogen cyanide is removed in scrubbing towers containing a suspension of elemental sulphur in water as a scrubbing liquor. It reacts with ammonia in the presence of hydrogen sulphide to form ammonium polysulphide, which reacts in turn with the hydrogen cyanide to form ammonium thiocyanate. A portion of the recirculating scrubbing liquor must be removed from the tower as blowdown and fresh reagents supplied to ensure that the ammonium thiocyanate does not inhibit hydrogen cyanide removal.

In order to treat this effluent, Dofasco uses a high-temperature, high-pressure wet oxidation system marketed under the name of Zimpro, which is widely used for treating industrial and municipal wastewaters containing oxidizable material. The unit was started up in 1983.

The sulphur-containing compounds in the effluent are oxidized to ammonium sulphate and sulphuric acid. This solution is returned to an existing ammonium sulphate plant for vacuum crystallization. The ammonium sulphate is marketed as a fertilizer. The sulphuric acid is used to absorb ammonia from the coke gas stream. Organic materials, such as tar and naphthalene, are converted to carbon monoxide and water. The gaseous portion, consisting mainly of water vapour, oxygen, carbon dioxide and carbon monoxide, is vented to the atmosphere.

Since these oxidation reactions produce more heat than is required to raise the feed to reaction temperature, external heat is required only during start-up or shutdown. All Dofasco's requirements for brine quality and vent gas composition have been met, except for carbon monoxide, but testing has shown this to be adequately dispersed.

Contact: Dofasco Inc.
Hamilton, Ontario

Reference: 91

9.8 MORRIS BEAN AND COMPANY (Yellow Springs, Ohio)

This foundry, which produces premium-quality aluminum castings, implemented a method of recovering spent chemically and clay-bonded sands used for cores and moulds. Two rotary kilns installed in series are used to thermally recondition the sand. The carbonaceous material surrounding the sand grains is destroyed. The sand is air classified to separate the fines and cool the sand.

The heat which is recovered improves fuel efficiency. The recovered sand is thermally stabilized. The loss on ignition (LOI) value of the recovered sand is lower than that of new sand, and the quality of the castings is improved. The operating cost is reported to be between $7.10 and $9.70 per tonne of reconditioned sand.

Contact:

Morris Bean and Company
Yellow Springs, Ohio
U.S.A.

References: 90, 95

9.9 OUTOKUMPU COMPANY (Espoo, Finland)

In order to alleviate the dual problem of increasing demand for chrome in the steel industry and a limited supply of high-quality lump ores, the Outokumpu Company developed a technique for producing ferro-chrome from all grades of chrome ore, including fines and ores with low chrome content.

The raw material is ground and pelletized. The pellets are sintered at about 400°C in a vertical shaft furnace, then preheated with coke and slag-forming materials. This mixture is fed into an electric smelting furnace. Energy consumption for this process is very low, because the feed mixture is preheated and because cleaned waste carbon monoxide gas from the furnace is used as a fuel for the sintering and preheating furnaces.

Cleaning of the waste gas is increasingly required for environmental reasons. The dust which is extracted is recycled to the pelletizing process. While no economic details are given, this process is reported to be economical compared with the cost of equipping old smelters for gas cleaning.

Contact:

Outokumpu Company
Espoo, Finland

Reference: 88

9.10 CP-312: Blast Furnace Fuel Made From Industrial Wastes

While the injection of supplemental fuels is a well-established way of decreasing consumption of metallurgical coal, a number of steelmakers are now making use of CP-312, a new, specially formulated hydrocarbon product derived from industrial wastes.

Liquid organic hazardous wastes (LOHW), produced by such industries as automotive, paper, chemical and paint manufacturing, are recycled into CP-312 at a number of regional manufacturing centres located near the industrial areas where the wastes are produced. The waste streams contain a wide variety of organic compounds, including ketones, alcohols and chlorinated solvents, as well as pigments and metals. The waste is processed and more than 98% of the original waste volume is recovered. This leaves little waste requiring landfill or incineration, and significantly reduces disposal costs.

CP-312 is a fluid chemical feedstock containing 59% carbon and 10% hydrogen, and has a calorific value of 12,500 Btu/lb. Using this product in a blast furnace does not represent a threat to the environment, since the very high temperature and closed-loop design ensure complete breakdown of the organic compounds in the waste. Steel companies make cost savings in two ways: CP-312 costs considerably less than equivalent amounts of virgin fuel oils and, since the formulation contains chlorine, there is no longer a need to inject chlorine to inhibit the formation of scabs on the interior walls of the blast furnace.

Contact: Cadence Chemical Resources, Inc.
Michigan City, Ind.
Reference: 98

9.11 Oil Recovery in Brass Processing

A technique developed in France and reported in 1982 permits a reduction in the oil emissions produced during brass turning in a conventional electric fusion furnace. Prior to entering the furnace, the brass stock is pressed into briquettes and the oil is recovered. The briquettes enter a drying furnace where more oil is recovered.

Besides the reduction in oil emissions, which improves working conditions, the heat of combustion from the recovered oil is used to heat the building and reduce overall energy requirements. The quality of the metal is improved and the yield increases by 2%. While the new procedure required an investment of $1,520,000 and costs $190,000/year, compared with an investment of $584,600 and annual costs of $58,460 for the old process, an annual return of $228,000 has been achieved.

Reference: 96

10.0 RUBBER AND PLASTICS

This industrial grouping covers two sectors according to the Statistics Canada classification system: the rubber products industries and the plastic products industries. The main product of the rubber products sector is tires. The plastic products industries include manufacturers of foamed and expanded plastics products, plastic pipes, films, bags, etc.

Typical hazardous wastes generated include aromatic process oils, halogenated and nonhalogenated solvents, petroleum hydrocarbons, phenolic solids and sludges, waste oils, paint wastes, plastics and resins. Many of the wastes produced by this sector are inert or contaminated solid wastes with no apparent recycling potential at present. However, opportunities exist in reuse of scrap product and recovery of solvents and oils.

There have been many experiments using waste rubber (substandard tires, rubber pellets, etc.) in concrete or as a fuel, but in general these approaches have not yet reached industrial scale. The plastics industry, on the other hand, appears to be quite active in developing waste recycle and reduction techniques and in sharing information within the industry.

CASE STUDIES

10.1 B.F. GOODRICH COMPANY (Tuscaloosa, Alabama)

Azeotropic Distillation System for Solvent Recovery

Background

B.F. Goodrich has been using an azeotropic distillation system to recover solvents from its tire manufacturing operation.

Solution

The Dyne 1 system, manufactured by DCI Corp. of Indianapolis, Indiana, introduces live steam into the evaporator chamber in order to vaporize liquid solvents at a boiling point lower than that of the solvent or of water. (For example, xylene boils at approximately 300°F. With steam introduction, the azeotropic boiling point of xylene and water is 202°F).

A predetermined volume of contaminated solvent is introduced into an evaporation chamber by a feed pump. Low pressure (8-10 psi) steam is introduced into the contaminated bath through a sparging bar. The feed is recirculated continuously to provide even heat distribution and to keep contaminants in a fluid state. The system vaporizes more than 99% of the solvent. Solvent vapours are condensed and passed through a coalescer/separator to remove any remaining free water.

Once the concentration of solvent in the evaporation chamber drops below 1% by volume, the temperature in the evaporation chamber begins to rise. Once the vapour temperature reaches a preset level, the solvent-free residue is expelled. Once the residue has been drained from the evaporation chamber, all valves reposition and the system automatically begins a new distillation cycle. There are no convection surfaces, thus eliminating residue bake-on and minimizing system maintenance.

This system can remove a variety of contaminants from solvents, including: mineral oils; greases, waxes; dissolved and undissolved soaps; detergents; most fatty acids; dyestuffs and other colouring material; fine insoluble material such as metal particles, soil and dirt; dissolved solids; pigments and resins.

Equipment costs range from $75/gal capacity for large units up to $1650/gal capacity for very small units. Installation costs are additional. Operating costs are usually under $0.25/gal.

Benefits

- Savings depend on current solvent and disposal costs. B.F. Goodrich's unit paid off in less than a year.

For More Information...

Contact:	Walter B. Stumpff B.F. Goodrich Company Tuscaloosa, Alabama	Reference: 107

10.2 SONY MAGNETIC PRODUCTS INC. (Dothan, Alabama)

Waste Reduction and Energy Recovery Add Up to Savings

Background

Sony Magnetic Products manufactures audio and video tape cassettes. The plant in Dothan employs approximately 1,300 employees and produces about 15,000 lb of waste per day, including 6,000 lb of waste magnetic tape, 1,080 lb of wood waste and 6,100 lb of trash.

In the early 1980s, several waste disposal problems arose. The base film to which the oxide layer is applied for magnetic tape production is polyester, and has great tensile strength. The several tons/day of waste tape from Sony were causing heavy wear on equipment at the municipal landfill site, and the City of Dothan wanted Sony to find an alternative method of disposal.

Solution

A heat recovery system was purchased from American Environmental Inc. of Dadeville, Alabama. The system burns waste magnetic tapes, waste solvents, wood wastes (e.g., pallets) and trash to produce steam for the plant. Emissions from the system are well below legal requirements.

Benefits

- The system, which cost $530,000 installed, generates average net annual savings of $202,997.28 through reduced disposal costs and energy savings. Simple payback is less than 3 years.

For More Information...

Contact:	Sony Magnetic Products Inc. Dothan, Alabama U.S.A.	Reference: 105

OTHER EXAMPLES

10.3 SWEETHEART PLASTICS (Conyers, Georgia)

Sweetheart Plastics switched to a more efficient, two-stage granulator to regrind scrap plastic at its thermoformed packaging plant. Horsepower requirements for scrap regrinding were slashed by 80% and savings in power costs were reported in 1981 to be $46,000/year.

Contact: Sweetheart Plastics
Conyers, Georgia

Reference: 100

10.4 3M (Decatur, Alabama)

At its Specialty Film plant in Decatur, 3M developed a scrap-processing system that removes coating on plastic film and reprocesses uncoated film waste. More than 5 million pounds per year of film scrap are no longer landfilled. Savings in raw materials totalled almost $9 million in the first year of operation.

Contact: Michael D. Koenigsberger
3P Program Coordinator
Environmental Engineering and
Pollution Control Department/3M
P.O. Box 33331, Bldg. 21-2W
Saint Paul, Minnesota 55133
U.S.A.

Reference: 99

10.5 Conversion of Scrap Tires into Oil, Carbon Black and Pyrolysis Gas

Energy Conversion (Chadds Ford, Pa.) markets plants that convert waste tires into oil, carbon black and pyrolysis gas. A 50 t/day pyrolysis plant costs about $3.5 million; with additional hardware the plants can generate electricity. The company is currently operating a 36 t/day plant, with plans to boost the unit to 50 t/day capacity. The expanded unit will have a daily output of 30,000 lb of carbon black and 5,000 gal of oil. Energy Conversion claims that the economics of the process are good.

Enerco (Indiana, Pa) produces small plants that are less capital-intensive. The company currently operates a demonstration plant that charges 6 tons of scrap tires that are split in half lengthwise to ease storage and drain off water. Each charge yields about 500 gal or 70 million Btu of oil, 4,000 lb of carbon black and 30 million Btu of gas. Each charge is fuelled with up to half a cord of unseasoned hardwood. The oil produced is sold to a nearby apartment complex for $0.65/gal plus transportation. The carbon black, trademarked Ebon, is sold through a distributor for $0.25/lb, versus $0.32-$0.37 for virgin carbon black.

Contact:

Christopher Kenney
VP, Marketing
Energy Conversion
Chadds Ford, PA
U.S.A.

Miles Thomson
President
Enerco
Indiana, PA
U.S.A.

Reference: 104

10.6 Efficient Plastics Chillers and Mold Temperature Controllers

Chillers and mold-temperature controllers that recycle cooling fluid eliminate the need for fresh liquid supplies and liquid disposal. There are several types of recirculating or closed-loop chillers and controllers that are designed to save water by keeping it within the system. Air or water is used to cool a fluorocarbon refrigerant, which in turn cools the process water via a heat exchanger.

Some of the newest closed-loop fluid cooling systems, like the Free Cooling System from Process Products, have means of by-passing cooling units when ambient temperatures are enough to supply cooling. When ambient temperatures are high, the system chills water by mechanical refrigeration. When temperatures are low, water is diverted from the chiller and rerouted through a closed-loop coil circuit, where evaporation of the sump water cools the process water. The compressors do not run during evaporative cooling. The energy savings reportedly pay for the system in about 10 months.

Reference: 102

10.7 Melt Conveying System For More Efficient Injection Molding

Mold-Masters Limited designed a melt conveying system to fill the demand for more efficient injection molding of thermoplastics. By using a melt conveying system, the plastics molder can minimize cycle time, reduce energy consumption, eliminate the production of sprues and runners, lower reject rates and drastically reduce the amount of plastic scrap generated.

Contact: Mold-Masters Limited
233 Armstrong Avenue
Halton Hills (Georgetown), Ont.
(416) 877-0185

Reference: 100, 103

10.8 Styrene-Suppressed Resins Reduce Styrene Emissions

The Ashland Chemical Company reportedly produces a line of styrene-suppressed resins that can help reduce styrene emissions during the production of polyester products such as bathtubs and boat hulls. Based on the principle that any liquid evaporates only at the surface, the suppressed resin system is chemically designed to keep styrene below the surface of the polyester while both are still in the liquid state. Styrene losses can be reduced by 70% compared to nonsuppressed systems.

Although suppressed polyester resins are somewhat more expensive than the unsuppressed type per unit volume, their use produces definite cost savings because more of the styrene becomes part of the finished product instead of being volatilized. Without suppressant, about 1900 lb of styrene are lost per 40,000 lb tank wagon, while with it only 500 lb of styrene are lost. As well, plants can meet occupational health and safety regulations.

Contact: Ashland Chemical Company
Dublin, Ohio

Reference: 101

11.0 TEXTILES

The textiles industry in Canada includes more than 1,000 establishments producing a variety of fibres, cloths, yarns and floor coverings. Hazardous wastes produced by the industry include waste solvents, dyeing and finishing wastes and nonemulsified waste oils.

Recycle and reduction opportunities for this industry include recovery of solvents and reduction of wastewaters through process alterations and reuse of washwaters. Substitution of nonhazardous scours for scouring agents and grease recovery are other recycling opportunities.

CASE STUDY

11.1 J.P. STEVENS COMPANY INC. (Clemson, South Carolina)

Ultrafiltration System for Dye Recovery

Background

The J.P. Stevens Company is one of North America's larger textile companies. For more than a decade, this company has been recovering chemicals using ultrafiltration (UF). Indigo dye from the blue jeans operation, and polyvinyl alcohol (PVA) sizing, are two chemicals noted in the literature as being recovered.

Solution

The UF system was developed jointly by Clemson University, the J.P. Stevens Company, Union Carbide Corporation and Gaston County Dyeing Machine Company. (The last-named company remains the distributor of the equipment). It depends upon a carbon tube/membrane filter which mechanically separates liquid systems according to the size of the molecules or particles.

The membrane consists of an inorganic coating mechanically bonded to a porous carbon tube. Water passes through this loop and extremely small molecules (2 nanometers in diameter) are filtered out, leaving a more concentrated solution inside. The equipment is highly resistant to chemicals and abrasion.

Benefits

- The capital cost of the recovery system was estimated in 1981 to be about US $0.75/lb of PVA recovered. Operating costs were estimated to run between $0.12 and $0.20/lb of recovered PVA. At PVA costs of $1/lb, payback was estimated at about 15 months. (No cost figures were given for indigo.)

For More Information...

Contact:	J.P. Stevens and Company, Inc. Clemson, South Carolina.	Gaston County Dyeing Machine Company Stanley, North Carolina

References: 113, 115

OTHER EXAMPLES

11.2 ADAMS-MILLIS CORPORATION (High Point, North Carolina)

This company established a pilot operation to recycle spent nylon hosiery dyebaths containing disperse dyes and chemical auxiliaries (scouring, levelling and wetting agents). The dyebaths are pumped from the rotary drum dying machine to a holding tank for analysis and reconstitution with dyestuffs. An average of 30 batches can be dyed before discharge.

This has allowed a reduction of 19% in dye consumption, 35% in consumption of auxiliaries and 57% in energy. It is estimated that, as a result, wet processing costs have decreased by 4.4¢/kg, providing the company with annual savings of $12,240, for an outlay (in 1980) of $28,441 for conversion and analytical equipment.

Contact: Adams-Millis Corporation
High Point, North Carolina

References: 111, 114

11.3 DOMINION TEXTILES INC. (Valleyfield, Quebec)

The processes of bleaching and mercerizing cloth in a textile finishing plant customarily occur together. This makes recovery of the used caustic soda from the mercerizing process difficult. In Dominion Textiles' finishing plant, however, the two processes are carried out separately. The cloth is scoured and bleached to clean it, and then mercerized by dipping in a 25% solution of caustic soda. Caustic recovery is feasible because the used caustic solution is relatively clean. The washwater is also recycled through a Swenson double-effect vacuum evaporator to recover more caustic.

The company estimates that it has reduced its demand from 300 tons of caustic/month to 90 tons as a result of these measures. Since the price of caustic has increased manyfold in recent years, recovery is worthwhile. Savings are also made in energy costs by preheating the boiler feed water with heat recovered from the condensing steam for the evaporator.

Contact: Dominion Textiles Inc.
Valleyfield, Quebec

Reference: 109

11.4 DRUCKEREI FARBEREI AYSTETTEN (Aystetten, West Germany)

The scouring effluent from this printed-knit fabric operation contains knitting oils, antistatic agents, scour chemicals and caustic soda. The installation of a Bowe Contisol solvent scouring machine reduced aqueous discharges and contaminant loading and saved 55% of operating costs compared with aqueous processing.

Contact: Druckerei Farberei Aystetten
Aystetten, West Germany.

References: 112, 116, 117

11.5 HARVEY WOODS (Woodstock, Ontario)

A low-liquor dye machine, the Aqualuft^{TM}, has enabled this company to reduce the amount of effluent produced, since the liquor ratio is reduced, exhausting most of the dye onto the fabric.

The first company to use this system was Spinners Processing Company of Spindale, North Carolina, who installed the machine in 1977. After three years the company reported an overall cost decrease from $4,900 (for atmospheric beck dyeing) to $1,300 per week for every 22,000 lb of fabric dyed. A reduction in energy consumption played a major part in this reduction, through a 4-fold decrease in the amount of hot water and steam required.

Contact: Harvey Woods, Woodstock, Ontario. Reference: 110

11.6 HOLLYTEX CARPET MILLS (Southampton, Pennsylvania)

In order to reclaim dye rinsewater, this company uses a moving-bed carbon adsorption unit designed and constructed by the Calgon Corporation. The unit, which contains granular activated carbon, treats the wastewater and recovers 80% for reuse as process water. The remaining 20% is discharged to the sewer. The spent carbon is removed and reactivated in a furnace equipped with a wet scrubber to remove particulates before being recycled to the adsorber. Purified water from the adsorber is cooled and eventually recycled to the dyeing operation.

Contact:
Hollytex Carpet Mills
Southampton, Pennsylvania

References: 107, 108, 112

12.0 TRANSPORTATION EQUIPMENT

This sector includes more than 1,000 establishments involved in the manufacture of motor vehicles and aircraft. Typical hazardous wastes generated include waste oils, heavy metal sludges, paint sludges, chlorinated and nonchlorinated solvents, spent pickle liquors, cyanide solutions, halogenated and nonhalogenated solvents, PCB solids or sludges, halogenated still bottoms, acid and alkaline solutions, and waste jet and rocket fuels.

With such a wide variety of hazardous wastes being produced, it is not surprising that there are a number of recycle and reduction opportunities within this industry. These include recovery of acids, caustic, solvents and oil, reduction in paint use and recycling of pickling liquor.

CASE STUDIES

12.1 BUDD AUTOMOTIVE (Kitchener, Ontario)

Ultrafiltration Oil Recovery System Has Quick Payback

Background

Budd Automotive manufactures automotive chassis. The coiled steel used is oiled prior to forming and then washed clean before welding. The water from the industrial washers and die-washing equipment, along with cutting fluids, is heavy with oil, grease and solids.

Solution

In 1976, the firm purchased an ultrafiltration (UF) system from Electrohome to recover the oil used in the press shop. Electrohome's system is custom designed for each application and can be scaled down for use by small businesses.

The UF system breaks the oil-water emulsion so that a dilute oil solution can be recovered. The oil solution recovered from the UF unit is about 30-40% oil. An acid can be added to concentrate the solution to about 60-70% oil.

Some of the recovered oil is reused in the plant, and some is sent to Breslube Enterprises in Breslau, Ontario for rerefining. The remaining oil is mixed with lime to form a dried lime slurry which is disposed of at a landfill.

Budd is planning to install two more washing tanks with UF units attached.

Benefits

- The system, which cost $100,000, paid for itself in less than two years.

- The main benefit of the system is that it keeps the washwater clean for months, instead of weeks. Formerly, the washing system, which consists of four or five 8,000-gallon tanks, had to be emptied and refilled with fresh water every 3-6 weeks. With the UF system, tanks need emptying only once every 6-12 months.

For More Information...

Contact:
Garth Johnson
Plant Engineering Manager
Budd Automotive
Kitchener, Ontario

References: 121, 127

12.2 GENERAL MOTORS INC., GUIDE DIVISION

Climbing - Film Vacuum Evaporator and Oxidation System For Chromium Recovery Pays Off In Less Than Two Months

Background

The Guide Division supplies plated automotive trim, and thus faced the chromium disposal problems common to electroplaters. GM had been recycling stagnant industry rinses following the electroplating baths as a standard procedure. However, when the firm began production of electroplated plastic parts in 1969, escalating raw material and waste disposal costs prompted General Motors to investigate further recovery options.

Solution

A climbing-film vacuum evaporator, consisting of an etch tank followed by four rinse tanks, was chosen to provide more effective resource recovery. Three evaporators were installed on the plastics-preplate line, and a substantial reduction was noted in the amount of waste chromium being treated. Two electrolytic oxidation systems were used to recover chromium that remained in solution.

Benefits

- The capital cost of the three evaporators and two oxidation systems was $170,000. The first-year savings were 1.05 million pounds of chromic acid, or $1.18 million. Oxidation contributed an additional saving of 230,000 lb.

For More Information:

Contact:	General Motors Guide Division	Reference: 118

12.3 G.G. BUFFING AND PLATING (Longueuil, Quebec)

Ion-Exchange Chromium Recovery

Background

G.G. Buffing and Plating plates decorative copper, nickel and chromium on a variety of components and trim for automobiles and motorcycles. In 1984, the company decided to expand its facilities. However, because it is located in a high-density urban area, there was limited space available for expansion. While a conventional waste treatment system would have enabled the jobshop to meet municipal requirements of 5 ml/L each for copper, nickel and chromium, it would not have fitted into the available space of about 20 x 15 feet. Also, treatment would have meant an ongoing cost, whereas metal recovery equipment promised a payback.

Solution

A two-storey addition was built with the plating line on the ground floor and a chemical recovery system above it. Short-bed ion exchange systems designed and built by Eco-Tec of Pickering, Ontario were installed on the copper, nickel and chromium rinses late in 1984 and started up in 1985. (Detailed information on the system's operation is provided in the references.)

The recovery equipment arrived at the plant as pre-assembled, skid-mounted automatic units. G.G. Buffing personnel installed the units following written instructions provided by the supplier. Eco-Tec started up the systems and trained G.G. Buffing workers to operate them. The plating manager monitors and maintains the units. This has required an average of 1-1/2 hours per day.

Benefits

• Total annual savings (in avoided treatment, disposal and raw material costs) for the first year were $13,257. Projected annual savings once the line reaches full capacity of 6,000 hours/year are $60,222. The installed cost of the recovery system (approx. $125,000) was comparable to that of a destruction/precipitation treatment system.

• The throwing power of the chromium plating bath has improved.

For More Information...

Contact:		
	Tom Nadeau Plant Manager G.G. Buffing and Plating 907 Tashereau Blvd. Longueuil, Quebec J4K 2X2	Mike Dejak General Sales Manager Eco-Tec Ltd. 925 Brock Rd. South Pickering, Ont. L1W 2X9

References: 128, 129

12.4 HAYES DANA INC. (Thorold, Ontario)

Recycling Metal Stamping Plant Wastes

Background

Hayes Dana Inc., Chassis Division produces die-cut and stamped metal components for the automotive industry. Production in 1984 was 470,000 automotive frames, 90,000 axle housings and 250,000 van extensions.

Prior to stamping, each metal component is coated with an oil-based forming compound. Once the stamping is complete, the parts are washed in a hot (70°C) alkaline cleaner (pH 12) in three batch wash tanks (each of approximately 28 m^3). These tanks had to be dumped every two weeks as cleaning efficiency deteriorated due to oil contamination. Waste was hauled off-site at a cost of $250,000 to $300,000 per year.

Solution

Consultants' review indicated that an ultrafiltration (UF) system was the best approach to reducing the plant's wastes. A pilot-scale UF system from Romicon was installed on one of the oil wash tanks in December, 1983 and performed successfully. A full-scale system was commissioned in April, 1985.

The system consists of two Romicon UF units; three Goulds 15 kW, 1800 L/min feed pumps (two on active duty, one on stand-by); one Tranter 1.9 m^2 plate and frame heat exchanger handling feed from all three hot wash tanks; four Goulds 0.75 kW, 110 L/min transfer pumps (three to deliver wash water from the wash tanks, and one to transfer processed waste oil between the process tanks); two 8.5 m^3 process tanks to hold the recovered concentrate; two 1.5 m^3 cleaner tanks to store permeate for UF membrane cleaning; and automatic level controls and control equipment.

The UF system draws dirty, warm wash water through a cooling tank to a process tank and then through two Romicon UF modules to separate the oily waste from the cleaner. The permeate (water, cleaner, surfactants, emulsifier) is returned to the wash tank for reuse and the waste oil solution is delivered to the process tank.

The influent to the UF system is always drawn from the process tank, so that the concentration of oil in this tank continually increases. Once the concentration reaches approximately 2%, or when the permeate flow rate decreases to less than 4.5 L/min, the influent is temporarily halted and the UF system is used to concentrate the oil in the process tank, returning the permeate to the wash tank. Once the waste oil in the process tank reaches a maximum concentration of 15%, the contents of the tank are pumped out and the waste oil sent for recycling or disposal.

UF membranes in the concentration unit are cleaned weekly using recovered permeate; those in the main process unit are cleaned monthly.

Benefits

- 30 m^3 of permeate are recovered daily, with some 4.5 m^3 of forming compound per day available for reuse.

- Total design, engineering, capital and installation costs were $282,000. The payback is less than one year.

- Total annual savings are $380,000: 50% savings in alkaline cleaner ($50,000); 90% reduction in waste oil hauling ($260,000); 20% saving in recovered forming compound ($70,000).

For More Information...

Contact:
Ralph Davies
Hayes Dana Inc.
Chassis Products Division
P.O. Box 1048
Thorold, Ontario
L2V 4P3
(416) 227-3751

Reference: 123

12.5 HUDSON BAY DIECASTINGS LTD. (Brampton, Ontario)

Chrome Recovery Pays Back Quickly

Background

Hudson Bay Diecastings manufactures and plates zinc die-cast parts such as mirror casings, door handles and plumbing hardware. The company was experiencing a heavy chrome drag-out problem with cup-shaped products and blind holes in die-castings.

Solution

In 1976, a chrome recovery system was installed, consisting of a series of drag-out tanks, a cation scavenger and a Corning evaporator. The system allows Hudson Bay to recover plating solutions exceeding 70 ounces to the gallon.

Benefits

- Before installing the recovery system, Hudson Bay used $400-$500 worth of chrome per week. Now they use about $100 worth -- a saving of 80%.

- The cost of disposing of the plating bath used to be at least as much as the cost of the chrome itself, approximately $500-$1,000 per week. This cost is avoided with the chrome recovery system.

- The system cost $95,000 installed. Payback is about 2 years.

For More Information...

Contact:

Mr. Don Bauman
Engineering
Hudson Bay Diecastings Ltd.
230 Orenda Road
Brampton, Ontario
L6T 1E9
(416) 453-5010

References: 119, 120

12.6 MODINE MANUFACTURING COMPANY (Trenton, Missouri)

Copper Recovery From A Brass Bright Dipping Solution

Background

Modine's Trenton plant manufactures a variety of sheet metal radiators. On a monthly basis, the plant processes about 225,000 lb of brass in its production of radiators for the automotive aftermarket, agricultural, and medium/light-duty trucking industries.

During production, metal surfaces are oxidized and coated with an oily film. These surface contaminants must be removed prior to assembling the manufactured parts into a completed radiator. Parts are passed through a hot alkali degrease, water rinses, an acidic pickle ("bright dip") composed of hydrogen peroxide, sulphuric acid and water, further rinses and an antioxidant coating.

Heavy metal ions build up rapidly in the bright dip solution, resulting in the precipitation of blue copper sulphate pentahydrate crystals. The rapid saturation of the bright dip solution with heavy metals and subsequent drag-in into the following rinses added significantly to waste treatment costs. As well, production was slowed by the need to remove crystals from the bright dip tank. The crystals were hazardous and required disposal.

Solution

An Eco-Tec Acid Processing Unit ion exchange column and a plating cell were added to the system. The hydrogen peroxide/sulphuric acid bright dip solution is continuously recirculated through the ion exchange column, which selectively removes the copper and returns the purified dip solution to the bath. Once the ion exchange column becomes saturated with copper, it is regenerated; the copper ions are fed into an electroplating cell, where the copper is plated out. The copper is then returned to Modine's suppliers for credit as No. 1 electrolytic copper scrap.

Benefits

- Capital cost of the equipment was $27,000. Annual savings from raw material savings, and avoided disposal costs are approximately $22,000.

- The system required 8 months to implement and paid back in approximately 14 months.

- A "moderate" increase in maintenance and personnel requirements is reported, but downtime is reduced and productivity has increased because of the elimination of copper sulphate crystals.

For More Information...

Contact:
James Egide
Modine Manufacturing
Trenton, Missouri
U.S.A.
(414) 636-1200

References: 124, 125

12.7 VULCAN AUTOMOTIVE EQUIPMENT LTD. (Vancouver, B.C.)

Replacement of Caustic Cleaning Process With Abrasive Aluminum Shot System

Background

Vulcan remanufactures used automotive engines. Components were cleaned of caked oil, grease, carbon and grime via wet application of caustic soda followed by scrubbing and rinsing. A caustic sludge generated as a by-product was stored on-site in tanks and the tanks were emptied two or three times a year.

Solution

A two-step cleaning system was implemented. The first step involves baking the metal parts to remove volatile oils and grease. In the second step, the parts are sprayed with a high-velocity stream of aluminum shot which thoroughly cleans them of grime and rust. In this step, the parts also acquire an aluminum coating which is rust-resistant and improves appearance.

Benefits

- The system produces no hazardous wastes. The aluminum dust by-product can be recycled. Savings in avoided disposal costs amount to $12,000 to $18,000 per year.

- Caustic costs were $5,400 per year; the aluminum shot costs only $1,500 per year. Water costs have been eliminated.

- Overall costs of operation were reduced from $17,000 to $15,000 per year, excluding labour. Labour costs were reduced by $25,000 per year.

- Productivity is reported to be enhanced by 45%.

- Equipment and facilities cost $75,000 and the system took 6 months to implement. Payback is estimated at 2 years.

For More Information...

Contact:
James Meikle
Vulcan Automotive Equipment Ltd.
648 W 6th Avenue
Vancouver, B.C. V5Z 1A3
(604) 876-3384

Reference: 126

OTHER EXAMPLES

12.8 FORD MOTOR COMPANY (Saline, Michigan)

The Ford Motor Company reportedly produced 14 million pounds per year of chrome-plated plastic parts in the manufacture of exterior automotive grilles for cars and trucks. In the process, 1.2 million pounds per year of unusable chrome-plated materials were being scrapped, at considerable cost.

Ford's Saline plastics plant installed a closed system to reclaim its chrome-plated ABS plastic scrap. The system, developed by Ford in cooperation with the Process Control Corp. (Atlanta, Georgia), feeds defective automotive grilles into a grinder, where they are precrushed and then reduced to half-inch pieces. A magnetic drum separator removes the larger pieces of metal that have been split off during grinding. The remaining metal and scrap go through a cryogenic feeder, where the scrap is cooled to almost freezing and additional metals splinter off.

The scrap then moves to an impact mill which reduces it to a coarse powder. The powder passes through another magnetic drum separator designed to remove the remaining metal from the powder. The separated ABS powder is 99% free of metal and is used as regrind in the plant's injection moulding operations. The metal scrap is sold to an outside reclaimer.

Operating costs are reported to be low; they include an operator's salary, approximately $5,000 per year in energy costs and the cost of the liquid nitrogen.

Contact:
Ford Motor Company
Saline, Michigan
U.S.A.

Reference: 122

12.9 GENERAL PLATING (Detroit, Michigan)

General Plating has operated a rising film evaporator unit since 1975. The company, which chrome-plates automotive parts, estimates that it has cut its chromic acid loses by 70%. The evaporator also recovers a proprietary mist suppressant used by the company. The savings in chromic acid (350 lb/day), treatment chemicals and avoided disposal costs were reported in 1977 to total more than $100,000 per year.

Contact:
General Plating
Detroit, Michigan

Reference: 120

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